Program and Project Effectiveness Monitoring Framework

King County River and Floodplain Management Section

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King County

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Glossary

Standard Monitoring: Monitoring data collected for repair projects that exceed 100-ft (30-m) in length or projects that include placed wood or other in-water habitat elements. Standard monitoring is intended to provide a broad base of information that can be used to demonstrate permit compliance, general environmental impacts and the success of achieving project objectives.

Enhanced Monitoring: Monitoring of larger projects intended to restore natural river processes to some degree, for example large scale levee setback and floodplain reconnection projects.

Special Investigations: Data collection and analysis targeted to address specific questions or floodplain management methods.

Reach: A segment of a river that might include several geomorphic reaches.

CHAPTER 1. INTRODUCTION

Monitoring Framework Overview

The King County River and Floodplain Management Section (RFMS) Monitoring Framework is intended to guide the collection of information related to program implementation, reach and river-scale processes, facility condition, and capital project performance in order to evaluate overall program and project effectiveness (Figure 1). The goal of the effectiveness monitoring program is to determine whether the actions and management alternatives identified in the Flood Hazard Management Plan (FHMP) are having the intended effects on flood hazard reduction, habitat condition, and cost effectiveness. In addition, the data collected will help inform future project design and program implementation (adaptive management).

Hypotheses and monitoring methods have been designed to determine whether the Goals of the FHMP are being met through project and program implementation. The **Goals** of the FHMP are:

1. To reduce the risks from flood and channel migration hazards.
2. To avoid or minimize the environmental impacts of flood hazard management.
3. To reduce the long-term costs of flood hazard management.

In order to assess effectiveness, the RFMS Monitoring Framework has three priority questions, including:

Has program and project implementation:

1. Reduced the risk of flood and channel migration hazards?
2. Avoided or minimized the environmental impacts of flood hazard management?
3. Reduced the long-term costs of flood hazard management?

The framework is designed to combine routine data collection activities (e.g., facility condition assessments, project effectiveness monitoring, etc.) with special investigations (project and policy-based investigations that cannot be answered using routine data collection activities) to determine program and project effectiveness. Due to the complexity of the RFMS work program, implementation of the monitoring framework is a multidisciplinary effort that requires the work of program managers, engineers, ecologists, geomorphologists, hydrologists, communications specialists, and economists. Development of monitoring methods is being coordinated among Water and Land Resources Division sections to ensure comprehensive and consistent monitoring of capital projects that will allow for programmatic decisions about project strategies. Organized and efficient data storage allows for multiple users to access data for synthesis and analysis, interpretation, and reporting (Figure 1). Results and recommendations will be considered when updating the FHMP, and will also be used to refine the monitoring framework as appropriate.

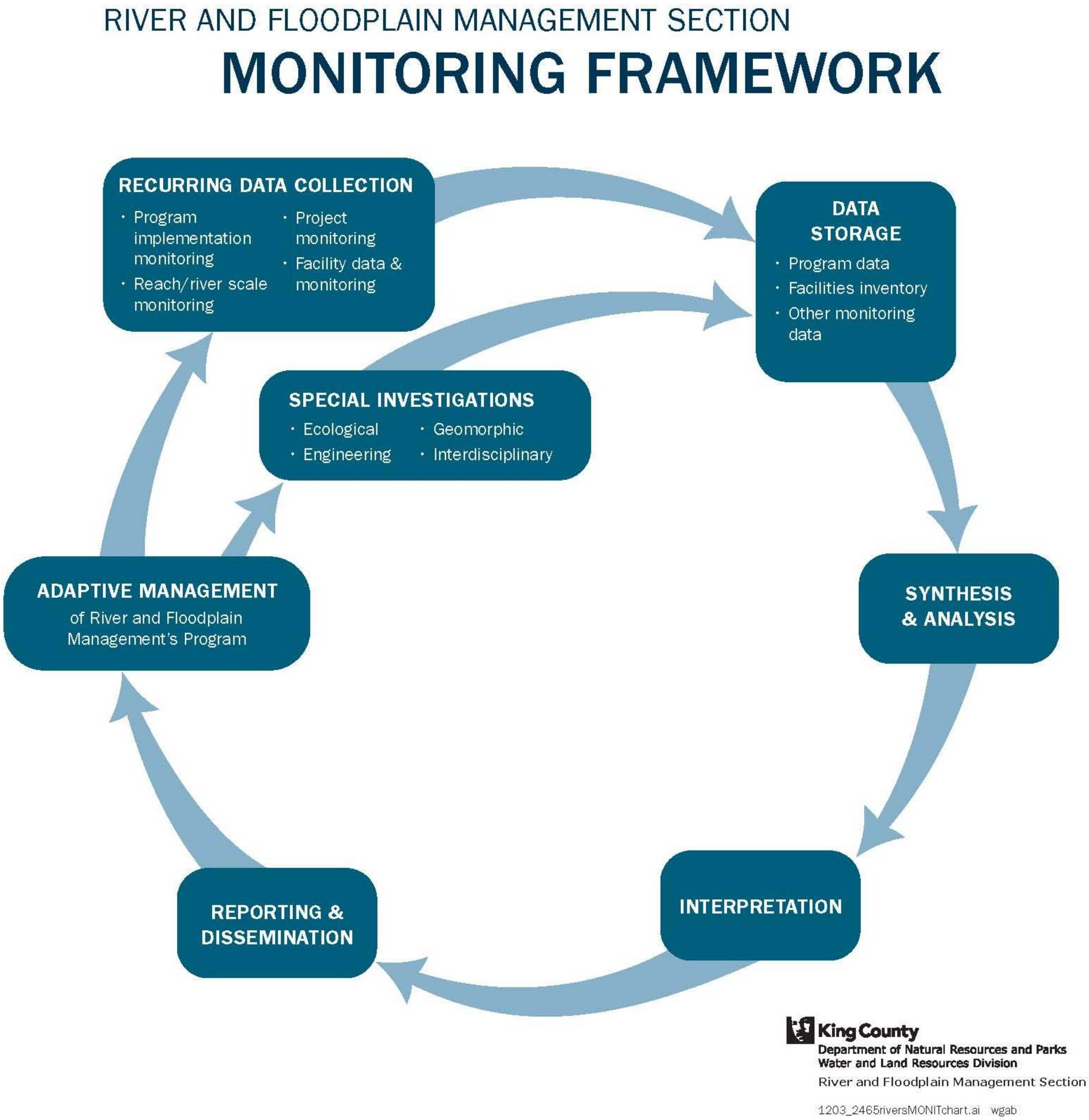


Figure 1. Schematic framework of the RFMS monitoring program.

This monitoring program is intended to be cost and time efficient so that it can be realistically implemented according to the suggested frequency. It will be implemented in addition to other WLRD sections' ongoing project effectiveness studies, reach-scale monitoring studies designed to test the effectiveness of multiple river restoration projects (e.g., Snoqualmie-at-Carnation, Rainbow Bend, Countyline, etc), and validation monitoring (e.g., fish population dynamics). Future reach-scale monitoring studies will be tied into this monitoring plan. Together, these efforts will allow for evaluation of the combined impact of individual projects on reach and river dynamics.

Individual project monitoring will also include hypotheses and methods designed to fulfill King County's permit-driven monitoring requirements from agencies such as the Washington Department of Fish and Wildlife (WDFW), Washington State Department of Ecology (DOE), King County Department Permitting and Environmental Review, other cities and counties, and the U.S. Army Corps of Engineers (USACE).

CHAPTER 2. MONITORING FRAMEWORK ELEMENTS

2.1 Recurring/Ongoing Data Collection

Program Implementation Monitoring

While monitoring and evaluation is most often thought of in the context of individual projects such as levee setbacks, this project-scale evaluation exists with the context of the overall risk reduction program so that the cumulative effect of projects, programs, and external land use decisions on flood and channel migration risk can be evaluated. Data collection efforts should enable an evaluation of whether the following fundamental objectives have been achieved via implementation of the 2006 FHMP:

1. Increased understanding of flood and channel migration hazards and risks in King County
    - Mapped vs. unmapped river or stream miles for flood hazards, and where appropriate, channel migration
    - Availability of future conditions modeling to evaluate build-out conditions, climate change, land cover change, etc.
    - Availability of hydraulic models to evaluate the impacts of major levee projects on flood elevations, backwater effects, conveyance capacity, etc.
    - Best available information – maps are updated and current
2. Communication of flood and channel migration risks to the general public and agencies concerned with risk management and emergency response
    - Implementation data on flood warning information distribution, vulnerable population outreach, flood alert subscriptions, and website hits
    - Survey data of flood awareness by basin compared to baseline
    - Survey data of regional partners, including Board of Supervisors, Advisory Committee, etc.
3. Actions that reduce the risk from the natural processes of flooding and channel migration.
    - Total exposure (residents, structures, critical public infrastructure, business activity) within the 1% and 0.2% floodplain by basin and by jurisdiction. Using census data, evaluate whether overall risk and vulnerability has changed over time. Where appropriate, provide this comparison at a reach-level (such as the 180th-200th St Corridor on the Green River)
    - Floodplain development permits, special use permits, reasonable use exceptions, and variances issued by basin and jurisdiction
    - Changes in impervious surface and land cover for floodplain development activity versus the baseline established as part of the 2011 FEMA NFIP Biological Opinion documentation in unincorporated King County.
    - Overall effect of completed and proposed levee setbacks on flood storage, conveyance, flood elevations, velocity, and sediment transport by river reach.

Reach/River Scale Monitoring

Basin and Corridor Descriptions

Text for the Snoqualmie, Cedar, Green, and White Rivers below is excerpted from the 2003 Programmatic Biological Effects Analysis (Johnson 2003), and updated with current information.

Snoqualmie River

Three major forks converge to form the mainstem Snoqualmie River. The South Fork Snoqualmie River begins near Snoqualmie Pass and flows generally northwest for 35 miles to its confluence with the mainstem upstream of Snoqualmie Falls. The I-90 freeway parallels the South Fork into the mountains. The Middle Fork, which begins in the Mt. Daniel-Mt. Roosevelt-Big Snow Mountain area of the Cascade Mountains, flows west and southwest 40 miles to its confluence with the North Fork about five miles upstream of Snoqualmie Falls. The North Fork originates in the Lennox Mountain area of the high Cascades and flows 26 miles to its confluence with the Middle Fork. The combined Middle and North Forks join the South Fork about 4.5 miles upstream from Snoqualmie Falls. The Snoqualmie River downstream of the forks flows over Snoqualmie Falls, then generally northwest and north, leaving King County just north of the town of Duvall. Important tributaries are Tokul, Patterson, Griffin, Harris, Ames and Cherry Creeks and the Tolt and Raging Rivers. Altogether, the three forks of the Snoqualmie and their tributaries plus the mainstem and its tributaries below Snoqualmie Falls account for 817 linear miles of stream in King County.

The King County Rivers Program inventory lists 225 facilities along 39.9 miles of riverbank both upstream and downstream from Snoqualmie Falls. Most are low and only contain high flows of 2-year recurrence interval or less.

The Raging River has a reputation for fast runoff and flash flooding, hence its name. Mean annual flow is 146 cfs; summer low flows are 9 to 15 cfs. Flood control levees have been constructed along the full length of both banks in the lower two miles of the channel near Fall City. In the 1960s, gravel was removed from the mouth of the Raging River as a flood control measure (Shannon & Wilson 1991). Channel migration zones occur from RM 5.8 to 8 and from RM 3.8 downstream to the levee reach. The principal means of channel migration in these areas is lateral migration (Shannon & Wilson 1991). Straightening of bends by cutoffs and short avulsions have occurred from RM 2.8 to 5.8; multiple channels have formed in the reach between RM 4.7 (the I-90 bridge) and 5.8, giving the reach a braided appearance (Shannon & Wilson 1991). The King County Rivers Program inventory shows eight scattered revetments that serve as erosion protection for individual parcels of property within these zones.

In the Tolt River, the dominant type of channel migration differs in different reaches (Shannon & Wilson 1991). Lateral migration is dominant from RM 5.9 to 5.0; avulsions and cutoffs appear to be dominating from RM 3.8 to 1.8, which gives this reach a braided appearance. Channel splitting and overflow side-channels occur downstream of RM 3.8, which is the upstream end of a large alluvial deposit known as the Tolt Delta. Although the King County Rivers Program has no facilities upstream of about RM 3.5 on the Tolt River, there are several private erosion control revetments upstream of this point. From about RM 2.0 downstream to the mouth, the Tolt River along both banks is confined between high levees that were built for flood containment. These levees are set back for long stretches near RM 2.0, allowing some degree of channel mobility in this area. These levees cut off connections with side channels, ponds and wetlands except for one location where a culvert maintains connectivity with an off-channel pond. A study of alternatives for levee setbacks and removals to reconnect some of these off-channel habitats is currently underway.

Cedar River

Prior to 1916, when the Montlake cut was constructed and the government locks and Lake Washington ship canal were completed, the Cedar River discharged into the Black River, which was also the outlet for the Lake Washington drainage. As part of the ship canal operation, the Cedar River was diverted into Lake Washington and the Black River outlet ceased.

The Cedar River originates in the Cascade Mountains near Stampede Pass and flows west-northwest nearly 50 miles to its present confluence with Lake Washington at Renton. The uppermost 10 miles flow through steep-sloped, narrow, forested mountain terrain in a channel characterized by high gradient riffles and cascades. Two water storage reservoirs, Chester Morris and Cedar Lake, occur in the next nine miles. Downstream from Cedar Lake to the City of Seattle water diversion dam at Landsburg (RM 21), the forested valley is alternately narrow and broad. While the river has many gentle-gradient reaches with good pool-riffle areas, the diversion dam is a total barrier to upstream migration of anadromous fish. The reach between the diversion dam and the Highway 18 Bridge at approximately RM 14.6 contains several high gradient boulder areas with only intermittent pool-riffle sequences. This is, however, an area of good gravel recruitment and high use by spawning salmon. The King County Rivers Program inventory shows several bank protection revetments along this reach. Rock Creek, a tributary used by anadromous fish, enters at RM 18.2.

Downstream of Maple Valley to the SR-169 crossing (approximately RM 13.4 to 11) is becoming heavily residential. Although levees at the upper end of this reach constrain the river and provide some flood protection, all of them overtop. The river meanders over a shallow, relatively broad valley through this reach, taking on a pool-riffle character with good spawning and rearing habitat for fish. Peterson and Downs (a.k.a. Taylor) Creeks, tributaries used by anadromous fish, enter at RM 13.8 and 12.8 respectively.

River mile 11 to 9 is referred to as the Belmondo reach. Here the gradient is moderately steep and the channel splits, even though bedrock along much of the left bank and an old railroad grade parallel to the river are major confining features. While RM 9 to 4.3, where SR-169 crosses again, has a series of revetments and training levees that confine the river, there is still opportunity for the channel to move in the vicinity of Madsen Creek (confluence at RM 4.5). Levees in this reach provide flood protection up to a 25-year event. The lower three miles of the Cedar River is heavily industrialized; downstream of the I-405 crossing (RM 1.6), the stream is channelized through the City of Renton and the Boeing manufacturing complex. The King County Rivers Program has no facilities in this lowest reach.

Green River

This drainage now consists of a single river system, the Green River, which in its lower 11 miles from Tukwila downstream, is also known as the Duwamish River. Formerly, the Green River was a tributary of the White River (confluence about RM 31 at Auburn); the combined flow continued down what was then known as the White River Valley (now the Kent Valley) to join the Black River at Tukwila to form the Duwamish. Diversion of the White River into the Puyallup reduced the flow in the lower 31 stream miles by more than half, and reduced the sediment supply to that portion of the system by about 75 percent (Mullineaux 1970).

The Green River begins in the Cascade Mountains on Blowout Mountain about 30 miles northeast of Mt. Rainier. It flows generally west and northwest for about 25 miles through a mostly narrow, steeply sloped, forested valley before coming to gentler slopes and broader valleys. At RM 68, the stream enters the reservoir behind Howard Hanson Dam, a flood control facility completed in 1962. The dam itself is at RM 64.5, and downstream of that, at RM 61, is the City of Tacoma water diversion facility, which represents the present upper limit of anadromous fish migration. The upper drainage, although mostly in Forest Service ownership, is managed as a municipal watershed. Downstream of the water diversion, the gradient remains steep as the river traverses the tightly confined Green River Gorge, emerging at Flaming Geyser Park, approximately RM 46.5. There the valley broadens and the river gradient suddenly moderates, causing deposition of large amounts of gravel. The channel is unstable here and can migrate erratically, taking on a braided character. This physically and hydraulically complex reach is among the most productive remaining mainstem areas for anadromous salmonids in King County (H. Coccoli, Muckleshoot Indian Tribe 1993, cited in Perkins 1993). Important tributaries in this reach are Newaukum, Crisp, Burns, and Soos Creeks. While the land use is largely agricultural, conversion to housing tracts is evident in places. Within Auburn, approximately RM 32, the river turns north and enters the broader, flatter valley where it had formerly been part of the White River. Industrial and urban land uses had rapidly replaced former farmland in this valley by as early as the mid 1970s (Ehrlich 1978). The former White River channel at Auburn has been filled in and is covered by housing tracts. Downstream of the former White River confluence at about RM 31, the channel gradient is low, flows are slow, and the river occupies a narrow channel confined within revetments and flood control levees. There are few if any gravel deposits within this lower reach.

The King County Rivers Program inventory lists 114 flood and erosion control facilities totaling 12.7 miles of stream bank along the Green River. Revetments and levees impede lateral migration of the Green River in many locations from Flaming Geyser Park (RM 46.5) downstream to Elliott Bay. Revetments and levees are present along at least one bank for just over 50 percent of the river’s length from RM 46.5 downstream to RM 25 near Kent, with most of the facilities concentrated in the lower portion of this reach (Perkins 1993). Containment of the channel by King County Rivers Program facilities continues downstream to approximately RM 6.6 (the SR-99 bridge), where the City of Tukwila and/or the U. S. Army Corps of Engineers assumes responsibility. The former Black River confluence is located at RM 11.

Howard Hanson Dam was built by U. S. Army Corps of Engineers in 1962. Outflows from the dam are regulated so that the flow at Auburn will not exceed 12,000 cfs, the equivalent of a two-year recurrence-interval flood prior to construction of the dam. The size of the two-year recurrence-interval flood at Auburn today is about 27 percent less than it was prior to construction of the dam (Perkins 1993). Though regulation has reduced magnitude of floods on the river, water stored by the dam during one flood must be released to create storage for the next. As such, the operation of the dam has also increased the duration of moderately high flows, i.e., those between 1,500 and 10,000 cfs (Perkins 1993). Since a large proportion of the sediment on the riverbed is mobilized by flows greater than 2,200 cfs, significant amounts of bank erosion can occur within this range of flows. Howard Hanson Dam also traps sediment from about 55 percent of the watershed upstream of Auburn, which has greatly reduced the sediment supply downstream. Alluvial and glacial deposits between Green River Gorge and Auburn continue to supply some coarse sediment to the river, as does Newaukum Creek (Perkins 1993). Soos Creek's sediment load, trapped in low gradient reaches within the creek itself, does not reach the Green River (King County SWM 1989; Perkins 1993). The result of this is that gravels in the Green River streambed give way to sand and silt at about RM 25.5, which marks about the lowest point at which salmon spawning occurs.

White River

Prior to 1906, the White River flowed through Auburn where it was joined by the Green River. From there it flowed through what was then called the White River Valley (now the Kent Valley) to its confluence with Black River, the outlet of Lake Washington, near present-day Tukwila. From there the combined flow, known as the Duwamish River, flowed north to Elliott Bay. In 1906, a flood-deposited debris jam formed at Auburn, diverting the White River south down an old overflow channel known as the Stuck River, into the Puyallup River in Pierce County. In 1915, a year or so before the government locks and Lake Washington ship canal were completed; this diversion was made permanent by construction of what is now referred to as the "Auburn Wall." A portion of the White River upstream from Auburn still lies entirely in King County, and much of the upper river, from RM 12.4 to the confluence of the Greenwater River at RM 45.8, forms the southern boundary of the county. The county boundary then continues east along the Greenwater River to the Cascade crest.

The White River, which originates from Emmons Glacier on the northeast face of Mt. Rainier, flows north more than 25 miles through eastern Pierce County to the town of Greenwater, where it is joined by the Greenwater River, a major tributary, at RM 45.8. The upper White River is a swift moving, glacial stream that carries a heavy load of sediment in a very dynamic channel. The river substrate consists of boulders, cobble, and large gravel. Near the town of Greenwater, revetments have been constructed to protect property, and a floodwall for flood protection.

Downstream of the town of Greenwater, the White River turns west and follows a meandering course. The channel gradient is about one percent with many channel splits, braids, and deep-cut banks. The Clearwater River, another major tributary, originates on Bear Head Mountain in Pierce County and flows north for 10.5 miles to join the White River at RM 35.3. Mud Mountain Dam, a flood control facility built by the U.S. Army Corps of Engineers in 1940's, is at RM 29.6. The upper end of the reservoir behind Mud Mountain Dam, when full, extends upstream past the mouth of the Clearwater River to approximately RM 35.5. Logging and recreation are the principal land uses in this reach along with some gravel mining for road construction. There are no King county Rivers Program facilities in this reach.

From Mud Mountain Dam downstream to the mouth of Red Creek at RM 27.5, the river channel is confined in a narrow, steep-sided canyon. The valley then broadens. The substrate consists of boulders, cobble, gravel, and considerable amounts of silt. Gravel riffles are located within the channel splits where channel migration has occurred. Puget Sound Energy's Buckley diversion dam at RM 24.3, which is a complete barrier to fish passage, now diverts water from the White River into the Lake Tapps Reservoir at an average annual rate of up to 75 cfs. The maximum instantaneous rate of diversion is up to 1000 cfs. The diversion rate (previously 2000 cfs) has been reduced since the Dieringer Powerhouse (White River Hydroelectric Project) ceased operations in 2004. In addition, the 2008 White River Management Agreement between Cascade Water Alliance and the Puyallup Tribe of Indians and Muckleshoot Indian Tribe set new minimum flow requirements for the White River. Fish are trapped at the Buckley diversion dam for transport upstream of Mud Mountain Dam. Boise Creek (confluence at RM 23.3) is a principal King County tributary in this reach. Boise Creek originates in the Cascade foothills upstream of a former Weyerhaeuser Company sawmill complex. While agriculture is the principal land use, there is a growing trend toward residential housing. The towns of Enumclaw and Buckley adjoin this reach.

From the PSE diversion, the White River meanders northwest toward Auburn. The Muckleshoot Indian Reservation straddles the river from RM 15.5 to 8.9. At RM 8.0, the "Auburn Wall" turns the river south down the old Stuck River channel to its present confluence with the Puyallup River in Pierce County. Water from Lake Tapps returns to the river at Dieringer, RM 3.5, in Pierce County. In this so-called "bypass reach," the valley averages about one mile in width with steep hillsides to about 400 ft. elevation. The channel carries a heavy sediment load and considerable channel splitting occurs. Except within the Muckleshoot Indian Reservation, where damaged levees and revetments have not been repaired or replaced, allowing the channel to migrate, the by-pass reach is highly channelized, especially downstream of RM 8.9, where it flows through the Cities of Auburn and Pacific.

In all, the King County Rivers Program inventory lists 31 erosion and flood control facilities along 5.0 miles of stream bank in the White River system.

The Greenwater River originates in a high valley on Castle Mountain north of Naches Pass and then flows generally northwest for 21 miles to its confluence with the White River. Approximately the upper one-third of the watershed is in the Norse Peak Wilderness administered by the U. S. Forest Service. The stream drops rapidly from its headwaters through a steep, narrow, V-shaped valley, over numerous cascades and a predominately bedrock and boulder stream bottom. Downstream of Burns Creek (confluence at Greenwater RM 8.2), the gradient decreases, the valley alternately widens and narrows, and the channel takes a more meandering course with occasional channel splits and braided reaches. In its lower four miles, the valley is relatively broad and flat. As recently as 1975, the channel from Burns Creek to the mouth was described as having a good pool-riffle ratio with generally stable stream banks consisting of earth or rock cuts or gravel-cobble beaches (Williams et al. 1975). A recent U. S.

Forest Service watershed analysis describes the channel and riparian conditions as being severely degraded and disturbed, largely as a result of the heavy logging (USFS 1996). Both the U. S. Forest Service and the State Department of Ecology have identified the Greenwater River as being in “unacceptable” condition and not protecting beneficial uses as required by the Clean Water Act (USFS 1996; WDOE 1998). While commercial forestry is the principal land use, the area also receives fairly heavy recreational use. The only populated area is near the community of Greenwater, near the confluence with the mainstem White River.

Skykomish River

The Skykomish River drains approximately 844 square miles of the Snohomish River watershed, more than the approximately 693 square miles of the Snoqualmie River basin. Only the South Fork of the Skykomish River flows in King County. The county line is near Baring, 56 miles upriver from the Snohomish River mouth (Williams et al 1975). Sunset Falls, between river miles 51 and 52 was a barrier to fish passage before fish were transported, beginning in 1958. The transport facility has been reported to provide anadromous fish access to 91.6 miles of habitat. A 1992 report stated 15 percent of the Chinook and 10 percent of the bull trout/Dolly Varden adult survivors in the Snohomish River system were upstream of Sunset Falls (Haring 2002).

The river valley is narrowly confined between steeply sloped mountains. The South Fork has several tributaries, including Barclay Creek, Index Creek, Lowe Creek, Money Creek, the Miller River, Maloney Creek, the Beckler River, the Foss River and the Tye River (Williams et al 1975). Alluvial fans have formed at the confluence of these tributaries. The Town of Skykomish is on the alluvial fan of Maloney Creek. During a recent flood event, a road on the alluvial fan of the Miller River washed out.

A number of public, private and railroads are constructed in shore and floodplain areas. As a result, the South Fork is isolated from its floodplain between Index Creek and the Miller River. In several reaches, the river itself is confined by roadbed armoring (Haring 2002). Large wood was removed in conjunction with timber harvesting, primarily on the Becker River. This lowered pool frequency, increased water velocities and adversely impacted salmon spawning and rearing habitat. Forty-six percent of the South Fork Skykomish watershed is in the high hazard category for human-induced mass wasting potential (USFS 1997 in Haring 2002), thus increasing potential for habitat degradation. Recommended salmon habitat restoration actions in the WRIA 7 Salmonid Habitat Limiting Factors Analysis included:

- Restoring or improving floodplain function where constricted
- Completing cleanup of BNSF RR contamination in the Town of Skykomish
- Enhance riparian function by adding conifers and.
- Restore riparian function in areas where the floodplain is constricted (Haring 2002).

Corridor-scale Implementation and Effectiveness Monitoring

King County river corridor planning is underway, and completed corridor plans will be adopted as amendments to the 2006 Flood Hazard Management Plan. Corridor-scale implementation and effectiveness monitoring protocols will be established following finalization of the corridor plans. The RFMS Monitoring Framework will be updated at that time.

Channel and Sediment Monitoring

Introduction
King County has a sediment management program made up of two components, channel monitoring and sediment management actions, as described in Section 4.3.1 of the 2006 Flood Hazard Management Plan (FHMP). The channel monitoring component monitors sediment levels and their effects on flood water levels along parts of certain King County rivers, as described below. This section of the Monitoring Framework describes the channel monitoring program and also provides information on the overall King County sediment management program for context.

Problem statement
When channel gradient and confinement decrease, sediment transport capacity of a river is reduced, typically resulting in sediment deposition. An unconfined river channel can migrate laterally to accommodate deposited sediment or deposit river-borne sediment in overbank floodplain areas. However, a channel cannot migrate where banks are armored or access its floodplain in river reaches confined by levees. Deposition of sediment in armored or leveed river reaches can decrease flood capacity through the reach, which may result in an increased flood risk.

In order to consider and determine the best flood risk reduction strategy(s), information on sediment accumulation and its effect on channel capacity are needed. Quantitative measurements are collected to document the changes over time in in-channel sediment levels, identify any sediment trends and characterize associated changes in flood water surface elevations. By monitoring sediment levels in a channel, changes in the conveyance capacity of a channel or of a levee system can be identified and evaluated. Sediment monitoring results can be used to inform the consideration of the flood risk reduction benefits of various sediment management measures and the expected duration of those benefits, and for other river management purposes.

The 2006 FHMP recommendations regarding channel monitoring include:

- **SED-1**—The existing channel monitoring program should be continued and enhanced with clearly defined objectives, geographic locations, priorities, monitoring frequency, and reach-specific purposes for those channels monitored by King County. Channel monitoring should be funded at a level that ensures that the locations of sediment accumulations are identified, that changes in sediment volume are understood, and that the effects of sediment accumulations on channel capacity and flood risks can be characterized.

- **SED-2**—A sediment management program (per Figure 2) should be applied to all of the channels monitored by King County, with actions that include: establishing a flood risk threshold that would trigger action; evaluating potential actions if channel monitoring reveals that the risk threshold is exceeded due to sediment accumulation; and implementing an appropriate action that meets the established flood risk reduction goal and other relevant evaluation criteria. The sediment management program should be funded adequately to meet sediment management goals.

1. Channel Monitoring Program Goals and Objectives

   The sediment management program goals, and therefore the goals of the channel monitoring program, are the same as the three FHMP goals:
   1. To reduce the risks from flood and channel migration hazards
   2. To avoid or minimize the environmental impacts of flood hazard management
   3. To reduce long-term costs of flood hazard management

   Objectives specific to channel monitoring of sediment levels:
   - Conduct channel and sediment monitoring consistent with standard protocols.
   - Quantitatively measure in-channel sediment existing conditions and the changes through time, or trends, in the in-channel sediment conditions.
   - Calculate the effect of changes in in-channel sediment levels on flood levels, for both present existing conditions and in trends through time.
   - Use channel monitoring information and hydraulic modeling to determine if an identified flood risk threshold is being exceeded.
   - Identify when changes in flood water surface elevations are attributable to sediment accumulation.
   - Maintain past and current channel monitoring data in accessible conditions and format(s) for ongoing use by King County and others.
   - Conduct channel monitoring in a way that complements and supports the overall King County sediment management program.
   - Coordinate with other agencies and entities in the collection and dissemination of useful, accurate channel monitoring data.

Scope

<u>Program components of channel monitoring:</u>

The channel monitoring program includes monitoring in-channel sediment levels, identifying sediment trends, if any, and characterizing the resulting changes in flood water surface elevations.

<u>Geographic areas</u>

The river channels that are monitored by King County (or cooperating agencies) are identified in Table 1, listed in no particular order or priority. King County RFMS collects the data in most of these monitored channels. The City of Renton conducts its own sediment monitoring program for the lower 1.7 miles of the Cedar River and shares results with King County. The City of Auburn typically conducts cross section surveys in a 1.25-mile reach of the White River, although King County occasionally surveys those; in any case, White River cross section survey data are shared. Channel distances listed in Table 1 indicate the most consistently monitored reaches; distances may be increased for a specific study or purpose.

Most of these monitored river channels are located at the downstream end of a relatively steep tributary, or they are a mainstem river portion that is located downstream of such a tributary, or the channel flows along an alluvial fan. Most of these monitored river channels are confined by levees or revetments maintained by King County. Other river reaches or channels may be added to the monitoring program in the future as appropriate.

Table 1. Channels monitored by King County for sediment levels.

River	Approx River Miles	Description	Primary data collector
Lower Tolt	0.0 – 1.7	Leveed reach	King County
Lower Raging	0.0 – 1.5	Leveed reach	King County
SF Snoqualmie	2.8 – 4.5	Bendigo Br to I-90	King County
Main Snoqualmie	20.9 – 23.9	Carnation area	King County
Main Snoqualmie	32.9 – 34.4	Fall City area	King County
Lower White	4.4 – 10.6	Lower White	King County
Lower White	6.4 – 7.7	A St to R St Bridges	City of Auburn
Lower Cedar	0.0 – 1.7	Mouth to I-405	City of Renton
MF Snoqualmie	0.0 – 4.2	North Bend area	King County

Methods

In-channel sediment levels are monitored through periodic surveys of in-channel topographic elevations. Survey data are collected by various means, depending on the river, the channel setting and desired representation of the channel. Underwater (bathymetric) elevation data may be collected by boat, using a combination of survey-grade GPS combined seamlessly with sonar. Elevations of out-of-water channel areas may be collected by LiDAR. Underwater data that is collected at a sufficient density to create a topographic surface of the channel bottom may be merged with LiDAR data to create a single digital surface of the full channel. Underwater data collected in less dense cross-section configurations can also be combined with out-of-water LiDAR data to create a full-channel cross section. If the channel can be waded, elevation data may be collected, e.g., along established channel cross sections, by standard land survey methods.

Changes in surveyed sediment levels are used to calculate changes in sediment volume and rates of deposition within the monitoring reach during the period between surveys. In addition, changes in the elevation of out-of-water (gravel bar) topographic surfaces can be depicted in planview and corresponding changes in sediment volumes can be calculated through comparison of sequential digital surfaces.

The effect of sediment on flood levels is characterized using the channel survey data in cross section configuration in a hydraulic model to calculate resulting changes in flood water surface elevations that occurred between surveys. Changes in modeled water surface elevations are compared to changes in the in-channel sediment levels through same time period to evaluate the existence of a causative relationship.

The frequency of channel monitoring data collection in most monitored channels is approximately every two to five years. Data may be collected more frequently if significant channel changes appear to have occurred, e.g., after a major flood or following large-scale channel modifications. This approach is intended to avoid the cost and effort of annual sediment monitoring while maintaining a long-term monitoring database that documents the episodic nature of sediment movement and deposition.

Sediment level monitoring data are stored in RFMS files. Survey data typically are collected in XYZ format (with horizontal and vertical coordinates) and delivered in ASCII or ACAD files. The XYZ data are converted to Station-Elevation format to calculate channel changes at established channel cross section locations and for use in hydraulic modeling in the same channel monitoring reach.

Interpretation of results and reporting

Channel monitoring results are reported and interpreted in a technical report with a summary and conclusion regarding the extent and magnitude of changes in sediment levels and their effect, if any, on flood water surface levels. The effect of changes in sediment levels and changes in floodwater surface elevations are evaluated relative to an identified flood reduction goal or objective, as indicated in the 2006 FHMP (see Figure 2). If it is determined that there have been measurable changes in flood water surface elevations, that those flood water levels no longer meet an identified flood reduction objective, and that the changes in flood water levels are attributable to changes in in-channel sediment levels, then a sediment management action may be considered.

Results, conclusions and their use (Adaptive Management)

Feedback to the monitoring program

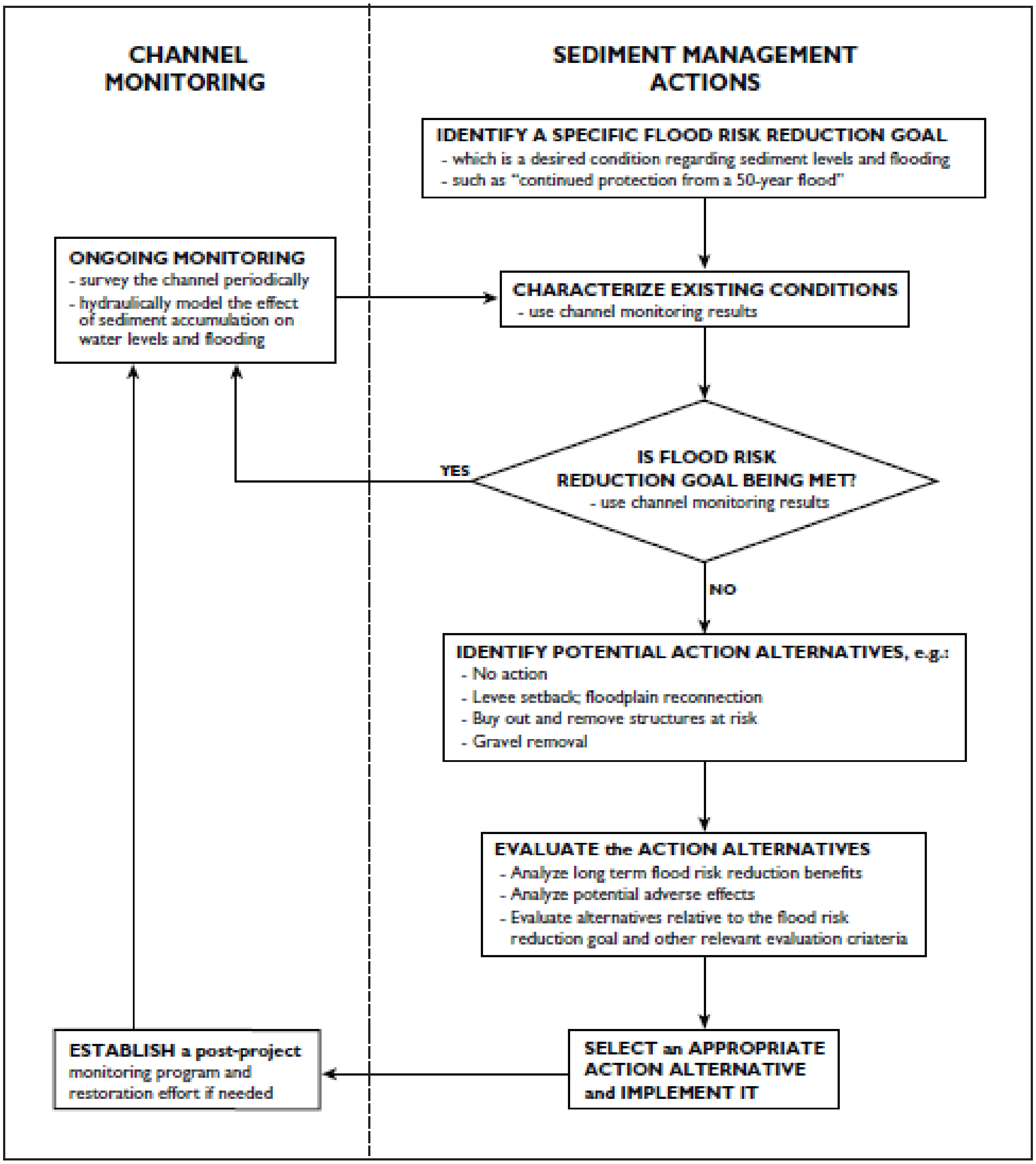
Ongoing in-house evaluation of the effectiveness of various channel monitoring techniques has resulted in refinements in data collection and reporting methods.

Feedback to RFMS monitoring framework

A review of the effectiveness of the overall sediment management program and its channel monitoring component, and its consistency with the RFMS monitoring framework, could be conducted through preparation of this Monitoring Framework document.

Feedback to flood risk reduction techniques

Channel monitoring results have been used in the consideration of different flood risk reduction techniques, e.g., in evaluating flood risk reduction alternatives and selecting a preferred alternative for implementation. Channel monitoring results will continue to be used in this capacity.



File name: 0604flmpFIG46.ai wgab Data source: Adapted from Kondolf et. al. (2001) Figure 44

Figure 2. A sediment management program and its components (King County 2006).

Coordination: internal and external to DNRP

Channel monitoring results with regard to existing condition and trends in both sediment levels and associated flood water surface elevations have been shared with other sections of the Division, where the information is relevant for use in designing projects for river facility repair or levee setback. Channel monitoring results, ranging from survey data to completed evaluations and technical reports; have been shared with other agencies and jurisdictions interested in sedimentation and its potential effects on flooding. Sharing channel monitoring data and information will continue.

Large Wood Studies

Introduction/Problem Statement

The 2006 King County Flood Hazard Management Plan (FHMP) provides strategies for managing flood risk on King County Rivers including recommendations for managing naturally occurring woody debris. Large wood is naturally plentiful in lowland rivers of King County, where it sustains critical habitat for threatened salmonids. These rivers now contain relatively little wood owing to flow regulation, bank hardening, forest clearing and direct removal. Wood is now commonly added to rivers to support regional salmon recovery efforts and fewer logjams are dismantled. Wood is also used as a structural component in levee repairs and in bank stabilization applications, where it helps to reduce near bed velocities and scour. These efforts are informed by an up-to-date understanding of how rivers work. Placement of wood in streams is now common, as evidenced by inclusion in federal, state, and local bank stabilization guidelines manuals[1].

However, some King County residents have expressed concerns that natural and placed large wood may also create hazards for recreational boaters, particularly casual users with limited experience. Some citizens have also expressed concern that increases in the amount of wood in rivers may have undesirable effects on private property and public infrastructure. These concerns point to a need for a more complete understanding of how King County river management practices have affected the amount and distribution of large wood in the past and to anticipate future changes. The following scope of work addresses data gaps for County staff managing these issues while responding to FHMP recommendation WD-4 which states:

"The Department of Natural Resources and Parks should conduct a study to assess where and how much large woody debris is likely to accumulate over time in various river reaches and approaches to maximize its ecological value while minimizing its risk. The study would have two parts: 1) a before and after assessment of large woody debris accumulations, complaints and flood and safety risks since inception of the current practice and 2) construction of a large woody debris budget, that would identify source or recruitment areas, transport reaches, and deposition or accumulation areas of large woody debris, and would identify potential future ecological benefits and risks associated with large woody debris accumulations. The large woody debris budget should be used to determine how, when, where and under what conditions future large woody debris management would occur."

Monitoring Program Goals & Objectives

The goals of this study are to:

1. Characterize historical changes in the amount and distribution of large wood,
2. Evaluate the effects of KC river management policies on current large wood conditions,
3. Anticipate how the amount and distribution of wood can be expected to change in the future on a decadal time scale if current policies continue.

The following study objectives are included to accomplish these goals:

[1] NRCS (2007), NEH-654 Stream Restoration Design CD; WDFW (2002), Integrated Streambank Protection Guidelines; King County (1993), Guidelines for Bank Stabilization Projects.

1. Develop a qualitative characterization of historical changes in the amount and distribution of large wood (1800's to 1990's) by looking at GLO surveys ad historic air photo records.
2. Use air photos to perform a retrospective study of large wood changes from 1993 – 2007.
3. Conduct an oral history float trip with ecologists and geomorphologists that have knowledge of changes in wood loading along rivers over the past 20 years.
4. Conduct a field study of large wood to determine storage and transport patterns and relate field data to air photo and Lidar data.
5. Conduct a land use and vegetation constituent patch study to determine potential wood loading rates and time frames.
6. Develop a large wood budget.
7. Conduct a recreational use study to determine the level of interaction between recreation users and large wood.
8. Create a river infrastructure inventory in GIS.
9. Analyze the wood transport effects of the 2009 flood using air photos.
10. Integrate all GIS data layers created in this study to produce a communications tool.
11. Investigate the potential to develop a large wood reach management strategy or tool.

Scope

The Cedar River was selected to pilot this study because County management of wood on this river has generated the greatest amount of citizen concern resulting from heavy recreational use. Additionally, like many King County rivers, management of wood on the Cedar River is constrained by federal ESA listing of salmon species. The tools used in this study will be scaled and designed so that they may be applicable for use in other King County river systems.

Methods

Each objective carries a suite of data collection activities. For Objectives 1, 2, 5, 8, and 9, air photo sets from 1993, 2007, and 2009 will be surveyed for apparent large wood pieces over 6 feet long and public infrastructure elements. Large wood data fields will be limited to location and an estimate of number of pieces. The public infrastructure elements recorded will include at a minimum bridge crossings and roads and trails within the 100 year floodplain. These data will be recorded in individual GIS layers.

The oral history float trip, Objective 3, will collect observations via written record and potentially videography. These records will be typed into MS Word documents for preservation.

Field measurement of large wood pieces and jams, Objective 4, will be conducted for up to five years including at least the summers of 2009 and 2010 and one additional year after a major flood event. Data collected will include wood size classes, number of pieces, orientation of wood relative to the bank, embeddeness, and apparent habitat functions. Wood considered 'potential key pieces' will be tagged for a transport study with red metal tags. Location data will be recorded using GPS equipment. Wood attributes will be recorded on paper and transposed to MS Excel spreadsheets.

A pilot recreation study, Objective 7, will be conducted in the field summer 2010. Data collected will include put in and take out locations, type of watercraft and life jacket use. Budget permitting, some study of recreation user perceptions of large wood in river systems will occur. This data will be stored in ArcGIS layers and MS Excel spreadsheets.

Objectives 6, 9, 10, and 11 are analysis steps that will require manipulation of GIS layers, potentially using the ArcGIS Model Builder tool, though the analysis methods are not yet determined. The wood budget exercise will follow methods developed by Latterell and Naiman (2007)[2].

Interpretation of Results and Reporting
Results will be interpreted first for scientific significance, then for practical significance or management implications. Because this study is important to help inform current policy issues and legislative measures, reports will be generated for the scientific, public administration, and public at large communities.

Adaptive Management
The reports generated from this study will be used to inform policy around large wood placement in projects and the management of naturally occurring large wood. The results of the study will need to be considered in the contexts of flood safety, recreational safety, endangered species habitat concerns, and river safety and maintenance budgets.

Coordination
The field and GIS study elements will be conducted internally by King County permanent staff and temporary hires. The recreation study will be shared with the King County Sherriff's Office, King County Parks, and the Cedar River Council.

Recreation Studies

Recreation studies have been conducted on the major King County rivers to allow for consideration of recreational user behavior, timing, and associated risks in project conceptualization, design, effectiveness monitoring, and adaptive management. More information can be found on the King County River and Floodplain Management website: www.kingcounty.gov/rivers.

[2] Latterell, JJ, RJ Naiman. 2007. Sources and dynamics of large logs in a temperate floodplain river. Ecol. Applic. 17:1127-1141.

Project Monitoring

Standard Monitoring

Introduction/Problem Statement
The purpose of this Standard Monitoring protocol is to guide implementation and effectiveness monitoring of RFMS projects using methods that can be applied in a larger context to capture cumulative effects. Larger scale RFMS projects may offer more opportunity to influence reach scale river dynamics and monitoring methods for those projects will be covered in the next section **Enhanced Monitoring**.

Monitoring Program Goals & Objectives

The goals of this standard monitoring program are to:

1. Ensure projects match design specifications and meet or exceed performance standards defined by regulatory requirements (*Implementation Monitoring)*.
2. Ensure installed hardscape project elements such as rock, wood, geotextiles, and soil lifts are intact and stable *(Effectiveness Monitoring)*.
3. Evaluate the site-specific and cumulative effects of modern era design flood facility projects on local salmonid habitats *(Effectiveness Monitoring)*.
4. Create a record of fish use of RFMS projects relative to control (both natural shorelines and 1960's era riprap facilities) sites *(Effectiveness Monitoring)*.
5. Improve construction and maintenance practices using monitoring results *(Adaptive Management)*.

The following program objectives are included to accomplish these goals:

1. Manage construction to ensure projects are built and restored according to design specifications.
2. Perform regular facility inspections (annual and post-flood) and condition assessments to identify structural issues.
3. Assess and quantify fish habitat at projects at specific times pre- and post-construction (through five years post-construction) and then once every ten years for the design life of the project portion of the facility.
4. Analyze data at various scales and in the context of other studies.
5. Report findings to permit agencies and other interested parties.
6. Utilize findings to improve project design and maintenance.

Scope (program components, geographic area)
The scope of this program will build upon ongoing RFMS monitoring efforts initiated to address monitoring requirements for KC Department of Development and Environmental Services (DDES) Clearing and Grading permit requirements. Monitoring efforts to date have focused primarily on reporting both quantitatively and qualitatively on success of vegetation establishment at repair sites as measured by plant survival and native plant percent cover, often using line-intercept transects. There is also some historic juvenile fish information from 2001 and 2002 monitoring efforts that may be utilized to support the development of these updated

protocols. Various mechanisms for monitoring and reporting have been employed in the last decade due to increasing demands on maintenance and monitoring staff time.

Updated Standard Monitoring program components will include a consistent approach to data collection, data management, data analysis, and reporting. As the KC Rivers monitoring program evolves over time, Standard Project Monitoring will be improved as new themes emerge from Best Available Science and standards of monitoring practice evolve.

The geographic scope of Standard Project Monitoring includes all King County rivers. Subsampling of projects may be necessary in a heavy construction year (e.g., multiple repairs following a large flood). Standard Project Monitoring will take place in conjunction with an Extensive Post-treatment Analysis identified under **Special Investigations** below. The two monitoring activities will use consistent protocols to gain a thorough understanding of how past and current Rivers projects are impacting juvenile fish habitat across basins. The Extensive Post-Treatment Analysis will include sampling of control reaches both natural shorelines and 1960's era riprap facilities, to allow for comparative analysis among project types.

Permit agencies, particularly KC DDES, often require annual monitoring reports that ensure vegetation survival and stability of some structures (e.g., placed wood). In lieu of typical permit compliance monitoring, RFMS proposes to measure the response variables below under *Methods* for new projects; pre-project (where possible), immediately post-construction, and years 1, 3, and 5 post-project. A sampling of projects will be monitored at subsequent 10-year intervals after Year 5 to gain a better understanding of long-term project effects. Because these protocols are more thorough than typical permit compliance monitoring requirements, it is likely that agencies will accept this proposed alternative monitoring which extends the monitoring timeframe, but eliminates some of the annual monitoring requirements. The potential exists to pursue a King County Programmatic Exemption from Shorelines Substantial Development Permits for Rivers repair projects. Negotiation to use a sampling approach under such an exemption to favor thorough assessment of projects as opposed to vegetation-only sampling of all projects may be possible and desirable.

Methods (data collection, frequency, storage)

The proposed categories of data and methods are designed to collect relevant data in a rapid, repeatable manner. Implementation monitoring should be conducted during and immediately following construction. A typical effectiveness monitoring sampling event for all other parameters should take a two-person crew no more than two days per site, with one day devoted to annual facility inspection, terrestrial vegetation, and large wood monitoring performed in the late summer (mid-August to late September), and one day devoted to juvenile fish and slow water monitoring performed in March. The following methods and data types were selected based on best available science and the ease in which results of data analyses could be compared with other local studies. In some cases a pre-construction monitoring event is identified. Pre-construction monitoring is not always practical for repair projects due to the emergency nature of the work. In some cases, an effort can be made to use air photos and LiDAR data to develop a pre-project record.

These Standard Monitoring protocols are to be applied to all repair projects that exceed 100-ft (30-m) in length or projects that include placed wood or other in-water habitat elements. Smaller or less complex projects may still require permit compliance monitoring, typically limited to vegetation monitoring. In such cases, it is recommended that the monitoring practitioner follow protocols IA1 and IA2 below for percent cover and survival monitoring so that those data can be included in the broad analysis of vegetation success on RFMS projects. In some cases those methods will not be practical due to area constraints and alternative methods such as census counts may need to be applied. Table 2 shows monitoring frequencies for each method described below.

Category I: Implementation Monitoring

Upon completion of the projects, the design drawings will be updated to become record drawings. The information for these record drawings comes from the Contractor's daily record drawings as well as the Project Representative's field records (daily records, photographs, inspection reports, field directives, and possible change orders) and post-construction site survey. Record drawings represent the best information available as to where improvements and changes from the original design have been made during construction due to unanticipated conditions encountered in the field. The record drawings will show sufficient detail to allow location of these improvements and changes for future monitoring or maintenance.

Category II: Hardscape Element Metrics (Facility Inspections and Condition Assessments)

Facility inspections will follow established protocols (see previous section **Routine Facility Inspections and Facility Condition Assessments**) and Appendix X for datasheets. Annual (low flow) facility inspections should be conducted concurrently with large wood and vegetation monitoring. Post Flood Damage Inspections should be conducted following significant flood events, and the same Facility Inspection forms should be used. Facility inspections should include an analysis of installed hardscape elements including rock, geotextiles, soil lifts, and wood, as well as identify any other maintenance needs such as weed management.

Category III: Vegetation and Large Wood Metrics

IIIA. Vegetation

Permanent vegetation monitoring transects will be established at each site. The number of transects established per site will be dependent on project area and the number of different vegetation treatment zones associated with the project. Transects will be a minimum of 15 meters and run parallel to river flow. In order to capture the difference between planting success at the toe and on the banks of the project, transects will be stratified into upland and riparian zones based on the project design. Transects will not cross design feature elements. A photo monitoring point will be established at the beginning and end of each transect looking upstream and downstream along the transect.

Metrics to be measured include:

1. Percent cover trees, shrubs, groundcover, and invasive plants will be measured using circular plots with a 3-m diameter at three locations, the beginning, middle, and end, of each transect. Percent cover will be estimated using Daubenmire cover classes to ensure repeatability of measurements. Percent cover will be evaluated every other year, starting at Year 1, defined as the end of the first growing season post-construction, Year 3, and Year 5.
2. Percent survival of planted specimens will be measured by running a 1 or 2-m wide belt transect along the cover transect established in (1) above and counting live and dead specimens by species. Survival will typically be monitored in Year 1. Year 2 survival monitoring may be required by permit agencies or desirable if poor plant performance is observed in Year 1.
3. All significant trees, defined as those greater than 12-inches diameter at breast height (dbh) will be measured and mapped with GPS in the extent of the project area to identify trees that may be impacted by development of access and staging areas. The project area is defined as the entire construction zone. Data collected will include species, dbh, and crown vigor class. Significant tree monitoring frequency will include three sampling events; pre-construction, Year 1 and Year 5.
4. Sedimentation will be measured only on benches that have been exposed to high flows. Sediment depth will be measured at the center of percent cover circular plots to the nearest centimeter. Monitoring frequency will include three sampling events, Year 1, Year 3, and Year 5.

IIIB. Large Wood

Large wood will be measured in three zones including; Zone 1, the extent of the project area, Zone 2, an area five channel widths upstream of the project area, and Zone 3, an area five channel widths downstream of the project area (Hassan et al. 2008). The extent of each wood measurement zone will include the area between of the active floodplains on both banks including the river. Wood metrics will be measured following the protocols established in the Cedar River Large Wood Study.

Metrics to be measured include:

1. For all wood pieces greater than 10-cm diameter and 1-m length, wood quantity and size will be recorded using a Montgomery classification system. Monitoring frequency will include three sampling events, pre-construction, Year 1 and Year 5.
2. For all key pieces, wood location and orientation will be recorded in a GPS database. Monitoring frequency will include three sampling events, pre-construction, Year 1 and Year 5.

Category IV: In-Stream Habitat and Juvenile Fish Metrics

IVA. Slow Water

Water velocity will be measured in order to map the area of low-velocity edge habitat available in each of the channel units described by Beechie et al. (2005). Measurements will occur in the three linear zones as described above for the Large Wood protocol, though the zone of measurement will be limited to the nearshore of the bank where the project occurs.

Metrics to be measured include:

1. Velocity: The midstream (waterward) margin (where water velocity is approximately <1.5 ft/sec) of the edge habitat will be located with a velocity meter and the slow-water boundary will be mapped at multiple points by GPS. Points and water margins will be transferred to a GIS to permit the area, number, and distribution of low-velocity edges to be quantified, and each habitat unit will be defined as bank, bar, backwater, or side channel. Monitoring frequency will include three sampling events, pre-construction, Year 1 and Year 5.
2. Depth: The depth will be measured at least three times along at least three transects perpendicular to the bank. At a minimum, measurements will be taken two, four, and six feet from the bank. If the area of slow water is wider, the perpendicular transects should extend at least as wide as the area of measured slow water.

IVB. Juvenile Fish

Juvenile fish use will be measured in the three linear zones as described above for the Large Wood protocol, though the zone of measurement will be limited to the nearshore of the bank where the project occurs. Specific methods and timing for juvenile fish monitoring will vary by site depending on site conditions. Ideally snorkel surveys will be conducted, however if those are not possible, seining, backpack electro-fishing, or another method will be used. Safety of surveyors is of paramount importance and permit guidelines will be strictly followed. Because measurement events will likely take place in the spring, with moderate to high flow conditions, some sites may be inaccessible for snorkel survey due to safety or turbid conditions. Monitoring frequency for all fish metrics will include three sampling events, pre-construction, Year 1 and Year 5.

Metrics to be measured include:

1. Species
2. Number
3. Size Class
4. Marked versus Unmarked (adipose fin clip)
5. Density by Zone
6. Habitat Unit (see Category IVA)

RFMS basin ecologist and maintenance and monitoring staff will develop an Excel spreadsheet database for housing these data. Ideally in future years the database could be upgraded to an

Access database and linked to the Facility Inventory. The database will include features to store and update data and photo records, as well as a calendar for scheduling monitoring events and reporting requirements.

Table 2. Sample monitoring timeline for standard RFMS projects.

	Year:				
Monitoring Method	**0**	**1**	**2**	**3**	**5**
Implementation Monitoring	X				
Hardscape Elements*					
Vegetation					
% Cover		X		X	X
% Survival		X			
Significant Trees	X	X			X
Sediment		X		X	X
Large Wood	X	X			X
Slow Water/Depth	X	X			X
Fish	X	X			X

*following flood events

Interpretation of results and reporting
Standard Monitoring data will be analyzed and interpreted according to best available science using the most current standards of practice. Results will be reported to all relevant permit agencies, County departments, and interest groups. In certain circumstances, particularly where novel approaches are taken, results may merit an effort at publication so other practitioners can learn about County project effectiveness. Data and results may also be used to aid in the development of **Enhanced Monitoring** protocols or **Special Investigations**.

Adaptive Management
Standard Monitoring results will inform the monitoring program by demonstrating whether or not effects can be observed using a specific suite of monitoring protocols. If effects are noticeable using the prescribed techniques, RFMS staff will have an idea of whether or not current facility design strategies are meeting desired objectives. If effects are not noticeable then RFMS will have the opportunity to determine if there are in fact no project effects, or if more appropriate tools and methods are needed to determine effects.

Coordination (internal and external)
There are a variety of other habitat monitoring programs in place at the King County Water and Land Resources Division. The continuing refinement of methods for Standard Monitoring will be conducted in concert with those other efforts. Additional results of these studies will be shared with tribes, permit agencies, the public, and the broader scientific community.

Enhanced Monitoring

Introduction/Problem Statement

Levees and revetments disconnect rivers from their floodplains and discourage channel migration and overbank flooding, processes which are instrumental in the formation of complex habitat for fish and wildlife (Ward and Stanford 1995, Kingsford 2000, Gergel et al. 2002, Larsen et al. 2006). Setback levees (facilities that have been moved landward from the river) and floodplain reconnection projects have been identified as a preferred restoration approach for increasing river meander potential while maintaining or reducing current levels of flood risk (Larsen et al. 2006). These projects, depending on the scale, allow for regeneration of floodplain forests, increased inundation frequency of riverine wetlands, reoccupation of historic side channels, and other natural channel processes that foster habitat complexity (Galat et al. 1998). All of these elements directly or indirectly improve salmonid habitat (Pess et al. 2005, Weber et al. 2009). Therefore, setback levee and floodplain reconnection designs have also been recommended as restoration projects in Pacific salmon conservation and recovery plans (Kerwin 1999, National Marine Fisheries Service 2006), and local funding and support has become available for levee setback projects in the Pacific Northwest.

Large scale levee setbacks and floodplain reconnection projects can also provide benefits in terms of flood storage, flood conveyance, and facility maintenance needs. Flood storage can be increased by connecting off-channel areas such as ponds or wetlands; flood conveyance can be increased by widening the channel. Facility maintenance frequency can be reduced if the setback facility is moved further from the active channel area, thereby reducing the amount of time or frequency with which a facility would experience damaging flows. Therefore, these projects have the potential to provide multiple benefits and meet the three goals of the King County Flood Hazard Management Plan.

King County has constructed and is planning to construct several large-scale levee setback and floodplain reconnection projects. An understanding of natural floodplain processes and baseline conditions is essential for planning river and floodplain restoration projects and for evaluating effectiveness (Ward et al. 2001, Pess et al. 2005). Because the science of floodplain restoration is still in development, restoration actions should be viewed as experimental manipulations linked to explicit hypotheses (Pess et al. 2005). The purpose of this monitoring plan is to evaluate whether large-scale floodplain reconnection projects on King County's major rivers effectively meet the stated project goals, objectives, and monitoring hypotheses.

Monitoring techniques focus on classic floodplain restoration elements (channel migration, side channel formation, habitat use, etc.), but may also vary among projects to investigate elements that are unique to the specific river basin. In general, the study reach will be monitored before and after project implementation to measure changes in physical and biological process as well as to assess the ability of the project to meet its stated objectives. A control reach will be established where possible and appropriate for answering specific questions. Because large rivers are dynamic systems, the responses of individual metrics are likely unpredictable and they may respond at different spatial and temporal scales. The use of similar methods among various floodplain reconnection projects within King County will allow for compilation of a larger dataset for evaluating multiple project effectiveness.

Monitoring Program Goals & Objectives
The goal of the enhanced project monitoring study is to explain whether levee setback or floodplain reconnection actions are producing the intended effects on flood risk, habitat conditions, watershed processes, and threatened fishes.

The following study objectives are included to accomplish this goal:
1. Measure channel processes, aquatic habitat, riparian processes, fish and other relevant wildlife, and water surface elevations in study reaches before and after project implementation. Sample within a control reach if applicable.
2. Analyze data at various scales and in the context of other studies.
3. Report on findings to interested parties.

Scope
The scope of Enhanced Project Monitoring includes monitoring several large-scale levee setback and floodplain reconnection projects completed by the King County River and Floodplain Management Section. The program components include data collection, data management, data analysis, and reporting. This is a collaborative monitoring effort with other sections in the King County Water and Land Resources Division, including Science and Ecological Restoration and Engineering. Rivers staff may participate as a monitoring team member on similar projects led by other King County sections. The Enhanced Project Monitoring protocols may be improved over time as new themes emerge from Best Available Science and standards of monitoring practice evolve.

Methods
Suggested methods are based on existing reach-scale monitoring plans for floodplain reconnection projects (Snoqualmie-at-Carnation, Snoqualmie and Tolt Rivers; Countyline, White River; Rainbow Bend, Cedar River; Reddington, Green River). Following a general framework and attempting method consistency will allow for maximum comparison of results among projects and river basins. When possible, the Standard Monitoring protocols should be included. Enhanced project monitoring can be broken down into the following categories, with suggested indicators listed under each category:

- Project Implementation
  - As-built condition
- Flood Risk
  - Structural stability
  - Flood elevations
  - Channel migration
- Channel Dynamics
  - Channel movement
- Aquatic and Riparian Habitat (includes vegetation)
  - Aquatic habitat (e.g., slow water, side channel/backwater connection)
  - Wood (stability and recruitment, if applicable)
  - Riparian Cover (survival and percent vegetative cover)
  - Invasive Plant Cover
  - Wetlands (if applicable)
  - Water Quality (if applicable)

- Fish (and, if applicable, wildlife) Use
    - Habitat preference
    - Habitat capacity

Measurable objectives, performance standards and adaptive management strategies should be tied to each indicator (see Enhanced Monitoring Plan Template in Appendix X).

Interpretation of results and reporting
Evaluation of the results will consider the results of univariate and multivariate statistical analyses (where possible), the observed magnitude and direction of changes in key variables, and interpretation of map products and graphical comparisons among time periods.

The focus during the evaluation step should be on drawing on all lines of evidence for a holistic evaluation of restoration effectiveness during the post-restoration period. An overarching question is, "*How have important indicators changed between baseline and pre-project time periods, and how did these indicators change in response to project activities?*" It is important to note that in dynamic systems, during the post-restoration period, the specific future values of indicator metrics, and the sequencing and extent of changes, may be largely unpredictable and should vary over time. This unpredictability does not constitute a restoration failure. Instead, successful restoration will be evidenced primarily by changes in impaired process rates; particularly, channel dynamics, streambed changes, riparian patch erosion, and wood delivery and retention, as well as increased edge habitat. These issues are explored further below.

How will monitoring results be applied and communicated?
In general, if the evidence confirms the monitoring hypotheses, the actions taken and techniques employed will be viewed as successful and worthy of application in future (similar) projects. If the hypotheses are not confirmed, or the evidence remains very weak, we will use the accumulated knowledge to explain (or speculate) why the desired outcomes were not achieved. Lessons from both 'successes' and 'failures' are valuable products from these studies; these lessons will be summarized in reports and presentations. The results of this study will likely provide valuable lessons and insights that can be applied to similar projects in the future, and to guide adaptive management decisions.

Adaptive Management
The project team should define acceptable adaptive management strategies before project implementation. These strategies should be linked to the performance standards (Appendix X). In general, if the evidence confirms the monitoring hypotheses, the actions taken and techniques employed will be viewed as successful and worthy of application in future (similar) projects and monitoring studies. If the hypotheses are not confirmed, or the evidence remains very weak, the accumulated knowledge will be used to explain (or speculate) why the desired outcomes were not achieved. Lessons from both 'successes' and 'failures' are valuable products from these monitoring efforts; these lessons will be summarized in reports and presentations. The results of this monitoring will likely provide valuable lessons and insights that can be applied to similar projects and studies in the future, and to guide adaptive management decisions.

Facility Data and Monitoring

Facility Inventory

The Facility Inventory project was initiated to develop a comprehensive understanding of the current condition of facilities operated and maintained by the King County River and Floodplain Management Section. The geographic scope (defined by Policy G-1 of the FHMP) of this work includes all rivers and streams that the Section provides flood hazard management services for, including: the South Fork Skykomish, Snoqualmie, Sammamish, Cedar, Green, and White Rivers, and Tolt River, Raging River, Miller River, Tokul Creek, Kimball Creek, Coal Creek (Snoqualmie), Issaquah Creek, Fifteen Mile Creek, Holder Creek and the Greenwater River. Facilities that will be included in the database include levees and revetments, a pump station on the Black River, and properties managed by the Section.

Problem Statement

The need to develop a detailed river facility inventory was first identified and recommended in the 1993 Flood Plan, and was developed over 2011 and 2012. This project was added to the KCRFMU's (now KCRFMS) work plan during the development of the 2006 Flood Plan to effectively manage flood protection facilities in a way that will address the following concerns:

- Many of the County's flood protection facilities are old (50+ years) and are reaching the end of their design lives. Tracking facility age and condition will inform likely maintenance and repair costs.

- Many facilities do not meet current design standards, andthese inadequaciesincrease the likelihood of failure or damage during high flows and increase the cost of repairs.

- A comprehensive set of inspection, assessment, operations and maintenance procedures for County flood protection facilities has not been developed but is needed to prioritize County resources.

Goals and Objectives

Three specific project goals and associated objectives were developed to focus the work effort, listed below. Objectives have been identified as either near or long term. Near term objectives were met in 2014,

1. Develop a comprehensive understanding of the current condition of all facilities managed by the RFMS.

- Create a current day baseline data set for each facility by gathering existing information sources supplemented by facility field work and initial routine facility inspections (*Near-term*), and performing conditions assessments. (*Long-term*)

- Implement facility condition assessments for levees and revetments and associated appurtenances. Condition assessments are used to determine the adequacy of a facility to successfully perform its required design function. (*Long-term*)

2. Create an organized storage space for maintaining and accessing information related to facilities.

- Develop a flood protection facilities inventory database (which will be referred to as the Inventory Database) to store facility information, capable of being used to enter and store new and existing facility information as it becomes available. (*Near-term*)
- Provide in-house database management to continue to provide consistent quality control and day to day maintenance of the facility database.(*Near-term*)

3. Create and implement consistent methods for collecting information related to facility baseline data, inspections, condition assessments, and maintenance activities.

- Develop protocols and methods for the following activities:

  - Data collection (in-house and field) *Near-term*
  - Data entry (into the Inventory) *Near-term*
  - Identifying facilities' required design function, defined as the purpose or task for which a facility is expected to perform. (*Long-term*)
  - Implement a program of annual and post-flood facility inspections. (*Near-term)*

Data Collection Tasks

The specific data collection tasks included in the Inventory project, which are also pertinent to the Monitoring Framework, are further described below and include:

General Information
Routine Facility Inspections
Annual Facility Inspections and Flood Damage Inspections
Facility Condition Assessments
Facility Inventory

General information in this context refers to relatively static information about each facility that either does not change with time or changes infrequently. This includes information related to facility identification, physical characteristics, and geographic location.

Routine Facility Inspections include Annual or Biannual Facility Inspections and Post Flood Damage Inspections. The purpose of these inspections are to identify active or potential problems (including damage, maintenance needs, or noxious weeds) that may affect the functionality of a facility, eligibility requirements for federal funding for repairs, or affect a particular reporting requirement such as State noxious weeds reporting requirements.

Field inspections determine any damage or maintenance issues and identifies next steps to evaluate and address the problem further. The data collected from inspections is uploaded into the facility inventory. An example Facility Inspection Sheet is included in the appendix.

Facility inspections will be on-going and have a frequency of at least once per year for priority facilities selected by each basin. The inspection frequency for other facilities may vary. Facility inspection records will be stored in a searchable database for access and reporting.

Facility Condition Assessments

The facility condition assessments will be focused on levees and revetments and will include a detailed assessment and analysis on selected priority facilities to use in determining the adequacy of the facility to perform its expected design function. Expected design function in this context has been focused solely on engineering and geomorphic assessment as the measure of adequacy has been linked to codes and policies specific to stability and maintenance. This focus should be revisited to ensure that the outcome of this effort meets the Section's current needs.

The determination will use all available information, including data collected to date, the analysis results (where applicable), and professional judgment, to determine the adequacy of the flood protection facility to successfully perform its required design function.

- The measure of adequacy will be based on current standards of practice, to be applied in this order: applicable County codes and policies, applicable County design and construction standards and guidelines, and applicable state and federal design and construction standards and guidelines.

Technical analysis in some instances will require interdepartmental assistance, a consultant, or multi-disciplinary review, such as in the case of a need to perform a slope stability analysis, or analyze the structural integrity of a large cross-culvert, or have a fluvial geomorphologist conduct a follow-up inspection or analysis. Results and links to pertinent analyses and data will be included in the Facility Inventory.

To date, a pilot project has been conducted on approximately 25 facilities. This information will be used to continue to refine the methodology to provide a more streamlined and efficient method of implementation.

2.2 Special Investigations

The need may (and often does) arise for project and policy-based investigations that cannot be answered through the recurring data collection activities identified in the RFMS Monitoring Framework. These investigations may be specific to one field of study (e.g., ecology, engineering, geomorphology, policy), or may be interdisciplinary in nature. Some examples of study questions may include:

What fish exclusion techniques are most effective and cause least harm to fish?

What are the effects of woody vegetation on the structural stability of levees?

How does bioengineering affect habitat and fish use?

As Special Investigations are developed and implemented, the RMFS Monitoring Framework should be considered for the information it can provide for the study, the methods for organizing and storing data, and the ways in which information gathered is synthesized and applied to future decision-making processes.

Potential selection criteria for monitoring efforts include:

- The monitoring proposal would help provide needed empirical versus anecdotal data regarding levee standards regarding vegetation, slope, and bank treatments.
- The monitoring proposal would help achieve legal compliance with a permit, regulation or other requirement.
- The monitoring proposal would help streamline permitting, for example by aiding approval of a programmatic approach.
- The monitoring proposal could be a catalyst for regional action, in a manner consistent with the WLRD vision.
- The results would better position RFMS for financial assistance or support, through grant funding for example.
- Proposed monitoring would yield information that could be used to increase the effectiveness of the RFMS performance generally or by increasing cost effectiveness.
- The readiness of a proposal, the acceptance of methods, and the comparability of data to other data or previously-collected data might be a ranking criterion.
- Monitoring results would help evaluate the relative merits of CIP or other project alternatives, and in this way improve alternative selection.
- A higher priority could be designated for a monitoring proposal requested or supported by partner agencies, or subject to cost sharing.
- A higher priority could be placed on monitoring efforts that would help answer a monitoring hypothesis that has been identified as important.
- Monitoring results would provide information helpful to other sections in WLRD and DNRP to collaboratively achieve goals, for example control of noxious weeds.
- The monitoring proposal would help address a policy conflict or question.

CHAPTER 3. DATA STORAGE

3.1 Program Data

Project Tracker

The WLR Division project management system (PRISM) includes project scope, schedule, budget, and expenditure data for use in managing the capital program and providing reports to the King County Flood Control District Board of Supervisors, the King County Office of Performance, Strategy, and Budget, and other audiences. This includes current-year appropriations, project lifetime cost, expenditures to date, as well as anticipated schedule and expenditures for different phases of the project. Uncertainties related to project scope, schedule and budget are also documented, and projects are considered to be baselined at 30% design (or “Gate 2” in the WLR Divison’s project management manual)

Flood Mitigation

The mitigation properties Access database is a central repository of information regarding landowner contacts for acquisitions and elevations. Some of these parcels are targeted by King County based on existing planning documents and projects while others result from unsolicited landowner inquiries, usually following flood events. The database includes information on contacts with the homeowners, interest and eligibility for various FEMA grant programs, elevation and benefit-cost information if available, and links to the King County assessor’s records for each parcel. In addition to tracking landowner interest and comments, the data is intended to help inform mitigation strategy and grant opportunities.

Grants

The grants database provides a central source of information about external funding sources, including FEMA grants, public assistance, conservation futures, and other fund sources. The database is used to project future external revenue for the District’s financial plan, administer current grants, and track billing and reimbursement requests for grants.

3.2 Facilities Inventory

The facilities inventory is a centralized database with the following capabilities:

- Provide Rivers Section staff with a comprehensive source of information on all current flood protection facilities managed by the RFMS and provide tools necessary to query, sort, and compare data records.
- Store characteristic information on each facility, including but not limited to information that can be used to characterize physical, geographic, conditional aspects and store maintenance, damage, and inspection records.

The Inventory consists of the following elements:

- An electronic database (SQL server format) to store and maintain up to date records
- A user interface that combines mapping (similar to iMAP with Rivers and County specific GIS themes), and the capabilities of a relational.

- Aphysical, organized and easily accessible filing location to store paper copies of plans, drawings, pre-existing records, reports and special studies not available in digital format.

The following bulleted list (excluding all information types but those that will be compiled as part of this effort) is a summary of the types of information that are or will be (labeled future) included in the Inventory:

- General Information
- Inspection Records (summarized in Routine Facility Inspections section)
- Condition Assessments (based on most recent condition assessment, future)
- Maintenance activities (Levees, revetments, properties)
    - Weeding, mowing, mulching, irrigation, invasive vegetation
    - Demolitions (future)
- Monitoring requirements (e.g. SEPA, HPA, local permits, programmatic other, future)
- Any planned actions related to the facility, including proposed costs and timing (currently this would include planned actions in the 2006 FHMP, future).

CHAPTER 4. DETERMINING PROGRAM EFFECTIVENESS-VALIDATION MONITORING

4.1 Reporting/Data Dissemination

Annual reports to permit agencies
Reports are prepared and submitted to the King County Department of Permitting, local jurisdictions, Washington Department of Fish and Wildlife, Washington Department of Ecology, U.S. Army Corps of Engineers, National Marine Fisheries Service, and U.S. Fish and Wildlife Service to comply with permit-related project monitoring requirements.

Outreach activities
River and Floodplain Management Section reports or studies are published on the King County web site at www.kingcounty.gov/rivers. In addition, outreach strategy may be developed based on the audience that wants or needs the information. General public outreach may include issuing a news release, a mass mailing notice to a targeted geographical area, holding a public meeting. Outreach to a targeted audience such as a specific stakeholder group (e.g., recreation, salmon recovery, conservation, specific geographic area) may include a targeted mailing, holding a smaller community meeting, attending an existing meeting for an organization or preparing information to be distributed through targeted newsletters or social media.

King County reports/Peer-reviewed literature
As noted above, King County reports will be published on the King County website. Standard and enhanced project effectiveness monitoring reports will generally follow established templates (see Appendices). Special investigations may occasionally warrant preparation for peer-reviewed literature.

4.2 Adaptive Management

The 2006 FHMP identifies adaptive management as the preferred strategy to regularly reevaluate Plan implementation priorities (King County 2006). This includes the use of "state-of-the-art information management strategies and performance assessment tools to measure flood risk reduction and ecosystem changes associated with plan implementation." Communication among project managers, engineers, and scientists should be fostered through a peer-review process where construction techniques and project performance (structural, ecological, and economic) are periodically evaluated. This peer-review process along with the results of the RFMS Monitoring Plan shall inform future project design and program implementation, with the ultimate intent of better achieving all three Goals of the FHMP.

4.3 Collaboration with other Monitoring Efforts

Monitoring work conducted by the King County River and Floodplain Management Section is consistent with guidelines in the Water and Land Resources Project Management Manual (King County 2014). Methods and reporting templates are also consistent with other monitoring efforts used within the Water and Land Resources Division (WLRD). WLRD is working to better integrate monitoring efforts across capital programs and with basin-wide salmon recovery monitoring efforts. RFMS has been and will continue to collaborate with staff members involved in such efforts within WLRD, with the goal of creating a comprehensive and consistent Division-wide monitoring program that provides management the opportunity to act upon key findings. This monitoring program will also coordinate with the local watersheds as they develop monitoring and adaptive management plans following guidance from the State. The long-term goal is to provide data that addresses relevant identified stressors to ecological processes.

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APPENDICES

Appendix I: Data forms and methods for standard monitoring

RFMS Standard Project Monitoring

Category: Vegetation and Large Wood

Metric: Percent Cover Vegetation

Method: Point Intercept Along Transects Method

When to Use: The Point Intercept Along Transects method of vegetation sampling is a fast and relatively accurate method for measuring cover and species richness at all plant strata. This method is ideal for measuring vegetation on long vertical transects such as linear revetment repairs. The primary problem with the method is that it may underestimate the presence of rare plant species. Point intercept is therefore not a suitable method for identifying new infestations of invasive plants (use the line intercept method instead). It may also be challenging to identify all of the species present at a point where there are multiple layers of overlapping canopy. Studies should not be conducted in heavy wind that interferes with the precise location of canopy. The Point intercept along transects method is faster and easier than the line intercept method because data are collected only at points at set intervals along a transect, rather than along the entire transect. If detecting precise *changes* in species composition over time is of great importance, the point intercept and line intercept methods are superior to the visual estimates in plots method. If rare plant species are of concern, the line intercept method is superior to the point intercept method. If rare plant species are not of concern and overhead canopy is abundant, then the point intercept method is superior.

Protocol:

1. Select one 25-meter long transect that is representative of each plant community at the site. Transects are parallel to the river flow and proceed in the downstream direction of flow (zero is at the upstream end, 25 is at the downstream end). Select one transect for each major plant community in the project area. Treatment reaches may have distinct plant communities on the toe, lower slope, bench/ mid slope, and upper slope. Group zones if the plant communities are indistinct so that each vegetation community is only sampled once at a site.
2. Transects in different vegetation zones should all have the same start points at a given site, but each transect will have a different randomly generated sample start point. It is helpful to hang a piece of flagging to temporarily mark the transect start point once the first transect location is identified.
3. Stretch a 100-m measuring tape very tightly along the extent of a transect, being careful not to trample vegetation; clip clamps work well to secure transect ends.
4. Record the GPS coordinates at the transect origin (zero on the meter tape). Take a photograph from the transect origin looking along the transect.
5. Starting at the randomly generated number between 0.0 and 1.0 on the tape measure, begin to record the plant species at one-meter intervals along the transect (25 points). Multiple overlapping species may be recorded in the same strata at an individual point.
6. Working on one side of the transect tape only, use a plumb bob to identify plants shorter than about waist height by slowly lowering the plumb bob to the ground and recording

each species "hit". The plumb bob line should be in contact with the edge of the tape without distorting the tape alignment. You may have to gently move aside upper layers of plants to identify all plants at the point.

7. Use a GSP Densitometer to identify plants above about waist height. Stand next to the meter mark on the tape transect, look through the short side of the densitometer, level both leveling bubbles, center the cross-hairs in the circle, and identify any plants intercepted by the intersection of the crosshairs. Use binoculars to aid in identification. Use best professional judgment if there are multiple canopy layers since it isn't possible to move high canopy layers aside to directly view layers above.
8. Use six-letter species codes consisting of the first three letters of the plant genus and the first three letters of the plant species (e.g., *Phalaris arundinacea* = PHAARU).
9. Measure the width of the plant community using the tape or visual estimate.
10. **NOTE**: Some sample sites are too dangerous to walk on, or have too dense of an invasive vegetation community to reasonably run transects. At these facilities, run a transect at the top of the bank (or along the opposite bank if visibility is better) and use binoculars and best professional judgment to estimate vegetation cover at each point along the transect. When possible, access the toe from a safe site or view from a bend or the other side of the river in order to estimate cover on the lower slope/toe.

Est. Time: Approximately 20 minutes per transect

Equipment: Waterproof clipboard with paper storage and pencils
Data sheets on Rite in Rain Paper
100-m metric tape
Flagging tape
Permanent marker
Clamps to hold measuring tape in position
Densitometer
Plumb bob

Safety Notes:

- Vegetation monitoring field work involves walking over uneven terrain and through growing vegetation. Wear appropriate field clothing including boots and raingear as necessary.
- Provide an office-base contact with location where you will be monitoring and planned time of return.
- Bring cell phone in field in case of emergency and know where nearest medical facility is located.
- Young floodplain vegetation often hosts wasps nests. Use precaution and always look forward before moving ahead along a transect. If you have a known allergy, always bring an epi-pen and inform field partners about your allergy and how to use the epi-pen if needed.

Point Intercept Along Transects Data Form

Date: ______________________ Observer: ____________________________ Recorder: _____________________________

Site: _______________________ Transect Length______m [1]Random Start______m Point Spacing Interval _____m

Transect: T LS B/MS US Vegetation Class Width _______m

Camera Number: _____ Photo Number:__________ GPS Number: _____ GPS Point ID: _________ GPS Accuracy ______feet

Choose one:
Vegetation measured along transect_____
Vegetation estimated along transect: from same bank _____ from opposite bank_____

Infrequent Invasives:

Notes:

Species Code	Strata			Point: direction of river flow →																								
(Six Letter)	F	S	T	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

Strata Codes: F = forb; S=shrub ($\leq$ 10-cm dbh AND <5-m h); T=tree($\geq$ 10-cm dbh AND $\geq$5 m h). Height trumps dbh if there is an anomaly.
Transect Codes:T=toe; LS=lower slope; B/M=bench/midslope; US=upper slope

[1]For a one meter point interval this will be a randomly generated number between 0.0 and 1.0 (e.g., 0.3)

RFMS Standard Project Monitoring

Category: Vegetation and Large Wood

Metric: Percent Cover Vegetation

Method: Visual Estimates in Plots

When to Use: Visual estimation of vegetation cover is a fast and easy way to collect plant cover data. The key benefits of this method are the ease of use, the likelihood of detecting plant species that have a small amount of cover, and the ease in which a non-scientific audience can understand the data. The primary problem with this method is the potential for differences in observed cover among observers. This method is a cost-effective way to detect plant cover for permit compliance monitoring and to gather general information about plant species success at a site. If detecting precise *changes* in species composition over time is of great importance, the line-intercept method for percent cover or a frequency measure may be more appropriate.

Protocol:

1. Sample at the same stage of the growing season for each measurement event.
2. Identify a team of two staff trained in native and invasive plant identification.
3. Select 1-3 transects 50-m in length that represent the vegetation condition for each plant community at the site. If the site has very large areas of homogenous vegetation use ArcMap to randomly select starting points for three transects. If the site has smaller patches of unique vegetation types, select a transect line that runs through the center of the plot to avoid sampling the edge. Occasionally transect lines may need to take a bend to fit in a minimum of three sampling plots. Be sure to indicate in your notes any unusual aspects of the transect line for subsequent measurement events.
4. Permanently monument the start and end of the transect line with a t-post marking the transect name on both the post and a piece of flagging tape tied around the post.
5. Stretch a 50-m measuring tape very tightly along the extent of the transect.
6. Mark plot centers using rebar with a cap at 0, 10, 20, 30, and 40-m. Mark cap and a piece of flagging around the rebar with location data (0-m, 10-m, etc)
7. To identify the boundaries of each plot use a pre-measured 3-m rope. Use brightly colored hubs to mark at least four points at the perimeter of a circle with a 3-m radius around the rebar.
8. Record each species found in the plot.
9. Working in tandem with your field partner identify the cover class for each species recorded and indicate the cover class in the appropriate plot number location on the data sheet. Daubenmire (1959) cover classes are recommended for ease of use and commonality in the literature. Classes are 1 (0-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5(75-95%), 6(95-100%).

Est. Time: Approximately 30 minutes per transect (depending on length)

Equipment: Waterproof clipboard with paper storage
Data sheets on Rite in Rain Paper
Pencil
50 to 100-m metric tape
Rebar and caps
T-posts
Flagging tape
Permanent marker
Clamps to hold measuring tape in position on posts and rebar
3-m pre-measured rope segment
4 or more brightly colored hubs to mark bounds of circle

Safety Notes:

- Vegetation monitoring field work involves walking over uneven terrain and through growing vegetation. Wear appropriate field clothing including boots and raingear as necessary.
- Provide an office-base contact with location where you will be monitoring and planned time of return.
- Bring cell phone in field in case of emergency and know where nearest medical facility is located.
- Young floodplain vegetation often hosts wasps nests. Use precaution and always look forward before moving ahead along a transect. If you have a known allergy, always bring an epi-pen and inform field partners about your allergy and how to use the epi-pen if needed.

Vegetation Cover - Visual Estimates in Plots

Study Site:	Date:
Planting Zone:	Observers:
Plot Size:	

Cover Classes: **1**: <u>0-5%</u> **2**: <u>5-25%</u> **3**: <u>25-50%</u> **4**: <u>50-75%</u> **5**: <u>75-95%</u> **6**: <u>95-100%</u>

Notes:

Transect #:																	
Photo #s:																	
GPS point names:																	
Genus/species	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5

RFMS Standard Project Monitoring

Metric: Large Wood

Method: Tally Using Montgomery Classification System with Key Piece Measurement

Est. Time: approximately 1.5 hours for an average length repair

Protocol: **Individual Pieces of Wood**

GPS the upstream starting point of the wood measurement reach and take a photo from the wetted channel edge looking downstream. Tally all large wood that is >10-cm diameter and >1-m length in the active channel on the half of the river where the facility is located. This area extends from below the OHWM on the facility to the centerline of the river. Each piece of wood should be tallied in one bin of Montgomery alpha-numeric classification system length and diameter table. In the rare case that there is a side channel associated with the facility, keep the mainstem tally separate from side channel tally. For any potential "key pieces" (≥E4 classification) use an individual line under "Potential Key Pieces" on the Individual Pieces data sheet to record a unique log #, length, diameter, rootwad diameter, trapping mechanism, geomorphic functions, and habitat functions. Unique log numbers should be a six digit code that starts with the Project Identification Code (e.g., CL), followed by the letter "L" for log, then a unique three digit number representing the specific log you are counting in the reach starting with 001. Refer to Codes and Criteria sheet for descriptions of functions and circle all functions that apply. Take a GPS point at 1.6-m above the root-flare where diameter is measured and record the unique log # in the GPS device, then mark the log with chalk to keep track of what has been measured and recorded. Do not record measurements of any wood associated with log jams on the Individual Pieces data sheet.

Jam Wood

A log jam is defined for this study as any collection of wood that has three or more pieces, all greater than C3 classification size, that collectively provide geomorphic or habitat functions that cannot be attributed solely to any of the individual pieces. Use a new jam wood data sheet for each log jam. Record a unique jam number on the data sheet. Unique jam numbers should be a six digit code that starts with the study Reach Identification Number (C#, T#, R#), followed by the letter "J" for Jam, then a unique two digit number representing the specific jam you are counting in the reach starting with 01. For example, the first jam in Control Reach 1 should be coded C1J01 and subsequent jams C1J##. Record whether the jam is on the mainstem or in a side channel and whether or not the jam is a designed element of a flood facility. Record the jam type, trapping mechanism, geomorphic functions, and habitat functions for the jam as a whole, not the individual logs. Circle all functions that apply. Tally all large wood members of the jam that are >10-cm diameter and >1-m length in the active channel using the Montgomery alpha-numeric classification system to describe length and diameter. Mark each piece of wood measured with chalk as you go to keep track of the pieces counted. For any potential "key pieces" (≥E4 classification) create a unique log # as described above in the Individual Pieces section and use an individual line under "Potential Key Pieces" on the Jams data sheet to record the log #, length, diameter, and rootwad diameter. Take a GPS point at the center of the jam and record the unique jam number on the GPS device.

NOTE: If it is too deep to safely wade to and GPS and measure a key piece, include an individual record for it in the individual key piece or jam key piece data sheet and use the alpha-numeric tally codes to estimate piece size.

Equipment: Garmin GPS
PVC measuring sticks with tally codes on one side, cm on the other
Rite in Rain data sheets
Laminated key for coding
Field clipboard/pencils

Safety Notes: Proper wading safety equipment must be used –chest waders with wading boots and PFDs or drysuits with PFDs. Surveyors should remain within sight distance of each other. Natural and installed wood and rock may be unstable and slippery – care should be taken when wading.

Large Wood - Individual Pieces

Site/Plot	
Date	
Team	
Notes	

Mainstem Tally		**Diameter Class (m)**					
Individuals		0.1-0.2	0.2-0.4	0.4-0.8	0.8-1.6	1.6-3.2	>3.2
Length Class (m)		**2**	**3**	**4**	**5**	**6**	**7**
1-2	**B**						
2-4	**C**						
4-8	**D**						
8-16	**E**						
16-32	**F**						
>32	**G**						

Side Channel Tally		**Diameter (m)**					
Individuals		0.1-0.2	0.2-0.4	0.4-0.8	0.8-1.6	1.6-3.2	>3.2
Length (m)		**2**	**3**	**4**	**5**	**6**	**7**
1-2	**B**						
2-4	**C**						
4-8	**D**						
8-16	**E**						
16-32	**F**						
>32	**G**						

Potential Key Pieces (*Individuals*)

#	**L (m)**	**D (m) / RW D**	**Trap Mech**	**Geo Fxn**	**Hab Fxn**
			bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
			bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
			bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
			bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
			bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
			bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
			bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
			bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc

Large Wood - Potential Key Pieces (Individuals cont.)

Site/Plot	
Date	
Team	

#	**L (m)**	**D (m)**	**RW D (m)**	**Trap Mech**	**Geo Fxn**	**Hab Fxn**
				bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
				bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
				bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
				bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
				bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
				bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
				bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
				bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
				bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
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				bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
				bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc
				bnk/fac/bar/mcb	bd/pv/pp/ph/ps/cwi/cwd	nc/sc/cc

Large Wood - JAM

Site/Plot		**Date**	
Location	Main/Side Channel	**Team**	

Jam Tally		Diameter (m)					
Jam #		0.1-0.2	0.2-0.4	0.4-0.8	0.8-1.6	1.6-3.2	>3.2
Length (m)		**2**	**3**	**4**	**5**	**6**	**7**
1-2	**B**						
2-4	**C**						
4-8	**D**						
8-16	**E**						
16-32	**F**						
>32	**G**						

Facility?	**Jam type**	**Geo Fxn**	**Trap Mech**	**Hab Fxn**
Yes/No	BAJ/MJ/FDJ/BEJ/BTJ/Othr	bd/pv/pp/ph/ps/cwi/cwd	bnk/fac/bar/mcb	nc/sc/cc

Potential Key Pieces (in Jam)				**Notes**
#	**L (m)**	**D (m)**	**RW D (m)**	

Large Wood Codes and Criteria

	Code	Full Name	Description
Key Piece Attributes	L	Length	Length from end of rootwad to stem at 10-cm diameter
	D	Diameter	Diameter 1.6-m above root ball
	RW D	Rootwad Diameter	Average diameter measured in two perpendicular directions
Trapping Mechanisms (Trap Mech)	bnk	original bank	Bank from where log originally fell
	fac	facility	Engineered flood control or bank stabilization structure
	bar	bar	Gravel bar on the inside or outside bend of a river meander
	mcb	mid-channel bar/island	Gravel bar or vegetated island surrounded by water on both sides
Geomorphic Functions (Geo Fxn)	bd	bar deposition	Bar depostion that stores sediment locally
	pv	pool scour, vertical	Scour caused by vertical obstruction creates scour, eddy or dammed pool
	pp	pool scour, pitched	Scour caused by pitched obstruction creates eddy pool
	ph	pool scour, horizontal	Scour caused by horizontal obstruction creates underscour
	ps	pool scour, step	Scour casued by step obstruction creates plunge pool
	cwi	channel width increase	Wood deflecting flow into bank and causing local erosion/widening
	cwd	channel width decrease	Wood armoring bank and maintaining narrow channel
Habitat Function (Hab Fxn)	nc	no cover	No overhanging or submerged cover
	sc	simple cover	Simple overhanging or submerged cover
	cc	complex cover	Complex overhanging or submergered cover
Jam Classification (Jam Type)	BAJ	Bar Apex Jam	One or more key members downstream of jam with bar or island form downstream
	MJ	Meander Jam	Several key members butressing racked wood upstream, typ. outside meander
	FDJ	Flow Deflection Jam	Key members may be rotated, jam deflects channel course
	BEJ	Bench Jam	Key members along channel edge forming bench-like surface
	BTJ	Bar Top Jam	Unstable accumulation of wood on bar in bankful channel
	Other	None of the above	

RFMS Standard Project Monitoring

Category: IV.A. Instream Habitat and Juvenile Fish/Slow Water

Metric: Slow Water Edge Habitat, Depth, and Overhanging Vegetation (optional)

Method: Velocity measurement and GPS mapping

When to Use: for all edge mapping

Est. Time: approximately 3 hours for a standard length repair (this includes the upstream and downstream zones)

Protocol: Map extent and distribution of low velocity (<0.45 m/sec) edge habitat throughout Zones 1-3 at up to three flow levels (typically 50%, 75% and 90% of the January – June flows). Use GPS to map 2 lines; edge of water and velocity break, where flow velocities begin to exceed the specified threshold. Velocity break will be located with a flow meter attached to a GPS antenna pole and validated at least every 10 meters. Surveys will be repeated in exactly the same way at each flow level during the juvenile salmonid rearing period (Jan-June). GPS files will be differentially corrected and used, in conjunction with field notes, to create a shapefile that accurately represents the available edge habitat at that flow. Average potential juvenile capacity will be estimated by classifying the polygons into backwaters, bars, and banks (natural or riprapped) and extrapolating densities by species and habitat type, either from site-specific studies or from literature values (Beechie et al. 2005).

Within the slow water area (or along the sample transect), measure depth along at least three transects perpendicular from the bank, at least two times along each transect, in order calculate average and maximum depth for the site.

Optional: A third line, the waterward edge of overhanging vegetation, should be mapped in a third pass along the project site. Area of overhanging vegetation will be calculated using this line and the edge of water line.

NOTE: If it is too deep or otherwise unsafe to stand at the slow water edge line or the waterward edge of overhanging vegetation, use GPS to map the wetted edge, and measure the distance to both the velocity break and the waterward edge of overhanging vegetation using a lightweight (e.g., PVC) rod with pre-marked measurements. Repeat these measurements every 10 feet and record on the datasheet.

Equipment: GPS and antenna
Swoffer flow meter
Field notebook/pencils
Stadia Rod

Safety Notes: Proper safety equipment must be used – either drysuits and PFDs near deep fast-flowing water or PFDs near slower shallower water. Surveyors should remain within sight distance of each other. Installed wood and rock may be unstable and slippery – care must be taken when navigating along the bank.

Slow Water Edge & Overhanging Cover Mapping/Depth

Date/Time:	**Flow at ___________:**
Site Name:	**Surveyors:**
Weather:	
GPS Filename Wetted Edge:	
GPS Filename Slow Water Edge:	
GPS Filename Overhanging Vegetation:	
Notes:	

If unsafe to sample slow water edge and overhanging veg, measure distance from wetted edge every 10 feet and note distances below:

Slow Water Edge:

Distance from bank (m)

Overhanging Vegetation:

Distance from bank (m)

Depth:

Location	**Depth (m)**

RFMS Standard Project Monitoring

Metric: Juvenile Fish Use

Method: Backpack Electrofishing (from boat or on foot)

Est. Time: approximately 1 hour for an average length repair

Protocol: Electrofishing can be used to develop catch per unit effort indices. Sampling periods should be timed to capture target fish species during peak rearing (e.g., if there is a bimodal outmigration, the sampling should occur between the outmigration periods). If using a boat, launch boat at upstream access area. While electrofishing, the rower should maintain the same velocity as the current. Fish removed from the water should be placed immediately in coolers with air stones. Record the amount of time the electrofishing unit was supplying electricity to the water. If using a boat, row the boat to a downstream stopping point. Identify, measure, and record all fish captured. If more than 30 individual fish of one species are captured at any one site, subsample 30 fish, then count and identify species and length class for the remaining fish. Release the fish at least 50 feet upstream from the boat. Repeat methods for the next site downstream.

Equipment: Boat (if necessary) and electroshocking equipment with PFDs
Gloves
Radio
Coolers and airstones (with extra batteries)
MS-222 (if anesthetizing fish)
Buckets
Large nets and small dip nets
Measuring boards
Datasheets, pencils, clipboard

Safety Notes: Proper safety equipment must be used – this includes drysuits and PFDs for all surveyors. All surveyors must know how to operate and shut off electrofishing equipment. Rubber gloves and nets appropriate for electrofishing must be used. Boat should be inspected before each trip to ensure that is in proper working order. A Boat Safety Plan must be written and approved by all relevant supervisors before beginning this work.

Juvenile Fish Sampling

Page _____ of _____

Date/Time:	**Flow at _______:**
Site Name:	**Surveyors:**
Weather:	**Sampling method:**
Notes:	

Habitat Type	Sampling Time (mm:ss)	Wood (Y/N)	Species	Fork Length (mm)	Weight (g)	Ad Clip (Y/N)	Notes

Appendix II: Monitoring and Maintenance Plan Template

(from WLRD Project Management Manual)

Monitoring and Maintenance (M&M) Plan Template

Project Name:	
Date/Version:	
Approved by:	Project manager
	Monitoring & Maintenance staff
	Project client, if applicable
	Site custodian, if applicable

There are seven basic M&M-related tasks in the Planning Phase, listed in order below:

Task	Description
1	Use the M&M Guidance Table to determine whether an M&M plan is needed. Work closely with M&M staff, as appropriate.
2	If either plan is needed, determine the appropriate content and scale of the plan.
3	If monitoring or maintenance is to be performed, complete the required elements of the Project Summary.
4	If monitoring is to be performed, develop a Draft Monitoring Plan.
5	If maintenance is needed, develop a Draft Maintenance Plan.
6	Estimate costs for each plan in the Draft M&M Budget Spreadsheet.
7	Review draft plans with key staff and stakeholders.

This document is intended to standardize M&M terminology and to streamline planning efforts. This document is also intended to encourage early communication between the PM, design team, and M&M staff, as well as the long-term custodians of the facility or property. It needs to be initiated in the planning phase, but will evolve over time in parallel with project design, eventually being finalized at 100% design or even at handoff.

Monitoring and maintenance (M&M) can each be divided into several types of pre- and post-project activities, each with a distinct purpose:

- **Monitoring**: Defined as *the act of making observations and/or measurements for the purpose of detecting problems, demonstrating compliance with environmental permits and mitigation requirements, and evaluating project performance to improve future projects*. Includes:
  - Site visits
  - Regulatory, mitigation, and effectiveness monitoring (pre- and post-project), and
  - Facility and public safety inspections (e.g. built facilities and placed wood).

- **Maintenance**: Defined as *activities and site modifications carried out for the purpose of maintaining acceptable conditions on the project site, as established by permit conditions, project goals, and/or other requirements*. Includes:
  - Routine maintenance (e.g., watering, weeding) and
  - Adaptive management (major site adjustments).
  - Some pre-project site prep may also be considered a form of maintenance.

For less complex projects, this plan may replace “Inspection Plans”, “Public Safety Management Plans”, “Site Management Guidelines”, and “Operations and Maintenance Manuals”. For more complex projects, this plan may reference detailed monitoring or site management plans. The use of existing standardized protocols when they already exist is encouraged and may be required (e.g., Rivers Facility Inspection Forms and Stormwater Facility O&M Manual).

M&M Guidance					
Category	**Activity**	**Purpose**	**Is it required, recommended, or not applicable?**	**Frequency and duration***	**Considerations in planning phases**
Monitoring	**Site visits**	Identify maintenance needs, qualitatively assess site conditions	Recommended for all projects	Opportunistic, annually or semi-annual. Duration varies.	Provide for site access in design
	Regulatory monitoring	Demonstrate compliance with environmental permit conditions	May be required to demonstrate compliance with environmental permits.	Usually annually bi-annually for three to five years.	Propose targets and cost-effective methods
	Mitigation monitoring	Satisfy agreements and permits related to mitigation.	Required if project involves mitigation funding.	Usually bi-annually for five to ten years.	Address M&M in Mitigation Plan document. Negotiate achievable targets and methods with regulators.
	Effectiveness monitoring	Determine whether project is meeting goals and producing the intended outcomes	Recommended for projects with high cost, uncertainty, risk or public profile.	Annual, bi-annual, or event-driven (e.g., floods) for five to ten years.	Opportunity to improve future designs, demonstrate success
	Facility and public safety inspections	Formally document the integrity of facilities and assess conditions of concern to public safety	Usually required for engineered facilities and for projects that place wood in rivers	Annual or event-driven. Duration and frequency varies.	Role of inspections in addressing potential risks, and implications for design
Maintenance	**Routine maintenance**	Control weeds, remove trash, maintain access, care for plantings	Recommended for projects with planting, public access	Annual or as-needed	Design options that could reduce maintenance needs
	Adaptive Management	Use advance (scenario) planning to mount a timely and effective response to foreseeable but unacceptable outcomes	Recommended if there is a good chance a level of effort beyond routine maintenance may be necessary to make the project function properly	Event-driven or varies. Duration varies.	Role of adaptive management in responding to changes, and implications for design

**frequency and duration vary and should be determined on a project by project basis.*

Level of Effort (Scaling) Guidelines						
Level of M&M effort and planning *	**Site visits**	**Regulatory and/ or mitigation monitoring**	**Effectiveness monitoring**	**Facility and public safety inspections**	**Routine maintenance**	**Adaptive Management**
1	✓				✓	
2	✓	✓			✓	
3	✓	✓	(optional)		✓	✓
4	✓	✓	(optional)	✓	✓	✓

*The project team and monitoring and maintenance staff determine the type and level of monitoring and maintenance effort required based on the characteristics of the project.

I. Project Summary

<u>REQUIRED</u>

Vicinity Map
(insert figure)

Project goals: Make the project intent clear and unambiguous. Should be specific, measureable, achievable, relevant, and time-bound. Should relate to or match performance standards.

Conceptual Design Drawing or Mitigation Map (if applicable)
(insert figure)

<u>OPTIONAL</u>

Site & Parcel Information
Existing Conditions
Access
Public Use
Planning Context
Design Features

II. Monitoring Plan

Monitoring: Defined as *the act of making observations and/or measurements for the purpose of detecting problems, demonstrating compliance with environmental permits and mitigation requirements, and evaluating project performance for the sake of determining project performance and improving future projects*. Includes:

a. Site visits
b. Regulatory, mitigation, and effectiveness monitoring (pre- and post-project), and
c. Facility and public safety inspections (e.g. built facilities and placed wood).

Site visits (Levels 1-4)

A single site visit often encompasses multiple activities and purposes; this section refers to relatively informal visits to check on conditions, not more formal kinds of monitoring. Schedule time to check on general site conditions, detect problems, identify maintenance needs, and manage site stewardship. Specify how often site visits are needed (bi-annual, annual, semi-annual, quarterly, event-driven), list tasks and major factors of interest, and identify the staff that should do the work.

- Frequency:
- Tasks and factors of interest:
- Responsibilities:

Regulatory Monitoring (if applicable, Levels 2-4)

When submitting permit applications, propose useful performance indicators and achievable targets that relate to project goals and that inform ongoing maintenance. Regulatory monitoring may or may not differ from mitigation monitoring.

Regulatory performance indicators/standards and target values or conditions

Indicators	Design feature	Performance Target	Timing (years)

Methods for measurement and analysis, and outputs or deliverables:

Indicators	Monitoring Method	Timing/Frequency	Deliverables

- Responsibilities:
- Reporting Schedule & Agency Contacts:

Mitigation Monitoring (if applicable, Levels 2-4)

Identify any mitigation requirements and consult with regulators early on to ensure the performance targets are appropriate and achievable. Consider embedding the monitoring and maintenance plan in the Mitigation Plan, if one is required, to avoid redundancy. Mitigation monitoring may or may not differ from regulatory monitoring.

Mitigation performance indicators/standards and target values or conditions

Indicators	Design feature	Performance Target	Timing (years)

Methods for measurement and analysis, and outputs or deliverables:

Indicators	Monitoring Method	Timing/Frequency	Deliverables

- Responsibilities:
- Reporting Schedule & Contacts:

Effectiveness Monitoring (if applicable, Levels 3 & 4)

Scale effectiveness monitoring to project cost, uncertainty, risk, relevance to future projects, public profile, and available resources. As these factors increase, the scope of monitoring should increase. Targets should originate from the specific goals in the design report, if applicable. Select indicator(s) that can be used to measure achievement of key goals or attainment of a target value or condition. Identify potential corrective actions in case targets are not met.

Effectiveness performance indicators/standards and target values or conditions

Indicators	Design feature	Performance Target	Timing (years)

Methods for measurement and analysis, and outputs or deliverables:

Indicators	Monitoring Method	Timing/Frequency	Deliverables

- Responsibilities:
- Reporting Schedule & Contacts:

Facility and Safety Inspections (if applicable; Level 4)

Identify which types of inspections are needed, their frequency and duration. Identify existing forms that should be used (e.g., Rivers Facility Inspection Forms, etc.) or identify factors of interest and inspection criteria to guide the inspector. Explain the conditions of concern that warrant a closer look. Clearly indicate what deliverables should be produced, and explain the process and schedule for reviewing, revising, and approving them. If conditions of concern are observed during inspections, responses may be warranted, so clearly explain the response protocol. Assign responsibilities for decisions and responses.

Type	Timing	Factors of interest	Inspection criteria	Conditions of concern
Annual Safety Inspections				
Post-flood Safety Inspections				
Complaint-based Inspections				
Emergency Inspections				

- Responsibilities:
- Response protocol:

III. Maintenance Plan

- **Maintenance**: Defined as *activities and site modifications carried out for the purpose of maintaining acceptable conditions on the project site, as established by permit conditions, project goals, and/or other requirements*. Includes:
  - Routine maintenance[3] (e.g., watering, weeding) and
  - Adaptive management (major site adjustments).

The Maintenance Plan provides information that will be used during design and for estimating of long-term operation and maintenance costs. Maintenance staff should be included in the project team or consulted on maintenance needs. The duration of the maintenance period is adjustable and can be scaled to match the project needs and long-term site management needs. Anticipating corrective actions that may be necessary to restore project performance will help to ensure adequate resources are available.

Routine Maintenance (if applicable; Levels 1-4)

Describe each task and specify what, why, where, how, when the tasks will be completed. Also estimate the effort required, including the timing, duration, frequency, labor source, and materials to complete the task.

Example Tasks	Description	Effort	Responsibilities
TESC Removal	(Materials and quantities)		
Site Security	(Bollards & locks)		
Structures	(Maintenance, repairs & replacement)		
Maintenance Access	(Location, maintenance management)		
Public Access	(Location, maintenance management)		
Trash Removal	(Debris & fabric/collar)		
Signage	(Maintenance & repair)		
Weed Assessment & Treatment	(Weeds of concern, treatment methods)		
Plant Irrigation	(Plant numbers, water source, water withdrawal permits needed)		
Plant Replacement	(10-15% of initial planting)		
Fencing	(Install, Maintenance & Removal)		
Beaver Management	(Beaver deceivers, etc.)		
Contract Administration	(Labor source)		
Reporting	(Records and logs)		
Corrective routine actions to restore project performance (if not listed above)	(List potential (routine) corrective actions that may be needed to comply with permits or to meet project goals)		

[3] Some pre-project site prep may also be considered a form of maintenance.

Adaptive Management (if applicable; Levels 3 & 4)

Major corrective action may sometimes be needed to comply with permits or to meet project goals. In these cases, an adaptive management plan is warranted. For the purpose of this document, an adaptive management plan consists of scenario-planning in which a list of plausible problem scenarios are developed, conditions of concerns are described (and time-bounded, as appropriate), and a progression of potential actions are proposed to address each problem scenario. It is a planning procedure that helps to:

a) Determine whether there is a good chance that major post-project construction work may be necessary in order to make the project function properly or to address risk.
b) Proactively identify feasible solutions for consideration in permit applications, and
c) Help to address and manage stakeholder expectations.

Scenario	Description	Progression of Adaptive Management Strategies	Inputs
Identify and name a problem scenario	Describe a plausible problem scenario that would warrant a major response (beyond routine maintenance).	List feasible responses in order of increasing cost and complexity.	List the non-monetary inputs required to implement responses

Appendix III: Enhanced monitoring plan template

[PROJECT NAME]

PROJECT EFFECTIVENESS MONITORING PLAN

[RIVER, RIVER MILES]

[Permit reference number, if applicable]

[Date]

Authors:

King County Department of Natural Resources and Parks, Water and Land Resources Division
201 S. Jackson St, Suite 600, Seattle, WA 98104-3855

[1]Project Manager: Email: ; Phone: 206.263.0492

TABLE OF CONTENTS

PROJECT SUMMARY

Give an overview of the project

PROJECT SETTING

Explain the river, landscape, and other aspects relevant to the project.

PROJECT JUSTIFICATION

Flood Risk Reduction

Habitat Restoration

PROJECT GOALS AND OBJECTIVES

PROJECT ACTIONS

Describe the project actions in the context of how they are designed to meet the project goals and objectives

PERFORMANCE STANDARDS

Monitoring objectives and performance standards are designed to determine project effectiveness (Table 1).

Table 1. Performance standards. *Indicators listed below are examples*

Category	Indicator	Objective	Performance Standards	Adaptive Management
Project Implementation	As-built condition			
Channel Dynamics	Movement			
Habitat Benefit	Aquatic habitat			
	Wood			
	Riparian cover			
	Invasive cover			
	Wetlands			
Fish use	Habitat preference			
	Habitat capacity			
Flood Hazard	Structural stability			
	Flood elevations			
	Channel migration			

Monitoring Strategy

[Example: This monitoring plan will help evaluate the effectiveness a levee setback project intended to reduce flood risk and improve natural processes that create and sustain productive aquatic habitat.]

Monitoring Purpose

Explain why the monitoring needs to be done and what the purpose is.

Audience

The primary audiences for implementation and effectiveness monitoring results include:

Monitoring Design

Describe the study design

Monitoring Tasks and Objectives

Indicators, or evaluation metrics, are proposed for each performance standard (Table 2). These indicators are intended to be used for effectiveness analyses (comparisons between time periods) and interpretation of the overall project success.

Table 2. Indicators and monitoring methods for evaluating project effectiveness.

Category	Indicator	Performance Standard	Task	Monitoring Method	Timing (Years)	Output
Project Implementation	As-built condition		1			
Channel Dynamics	Movement		2			
Habitat Benefit	Aquatic habitat		3			
			4			
	Wood		5			
	Riparian cover		6			
			7			
	Invasive cover					
	Wetlands					
Fish use	Habitat preference		8			
	Habitat capacity					
Flood Hazard	Structural stability		9			
	Flood elevations		10			
	Channel migration					

Monitoring Schedule

Table 3. Monitoring schedule (*example shown below)*.

Task	Objectives	Pre-Construction Baseline	Post-Construction Baseline	Year 1 2017	Year 2 2018	Year 3 2019	Year 4 2020	Year 5 2021	Year 6 2022	Year 7 2023	Year 8 2024	Year 9 2025	Year 10 2026
1	Record Drawings		X										
2	LiDAR/air photos*	X		X		X		X					X
3	Edge habitat	X		X		X		X					X
4	Aerial photography*			X		X		X		X			X
5	Wood loading	X		X				X					X
6	Plant survival			X									
7	Percent vegetative cover			X	X	X	X	X		X			X
8	Fish sampling	X		X		X		X					X
9	Facility inspections*			X	X	X	X	X	X	X	X	X	X
10	Channel cross-sections*	X		X		X		X		X			X

*Additional sampling may be conducted during and following high flow events

Monitoring Protocols

Project Implementation

Upon completion of the projects, the design drawings will be updated to become record drawings. The information for these record drawings comes from the Contractor's daily record drawings as well as the Project Representative's field records (daily records, photographs, inspection reports, field directives, and possible change orders) and post-construction site survey. Record drawings represent the best information available as to where improvements and changes from the original design have been made during construction due to unanticipated conditions encountered in the field. The record drawings will show sufficient detail to allow location of these improvements and changes for future monitoring or maintenance.

Channel Dynamics

Habitat

General Site Conditions

Surveyors will note general site and habitat conditions on field datasheets. This should include observed fish and wildlife use (direct observation of live or dead animals or indirect observation of prints, scat, etc.), general patterns of vegetation condition, invasive vegetation, illegal use or dumping, deformation or damage (movement of installed wood, bank erosion, etc.), and anything else considered worth noting.

Aquatic Habitat

Wood

Riparian and Invasive Plant Cover

Wetlands

FISH USE

Habitat Preference

Habitat Capacity

FLOOD HAZARD

Structural Components

Flood Elevations

Channel Migration

Adaptive Management

Specific adaptive management strategies are outline in Table 1. The expected outcomes of this monitoring effort are:

- …

In general, if the evidence confirms the monitoring hypotheses, the actions taken and techniques employed will be viewed as successful and worthy of application in future (similar) projects and monitoring studies. If the hypotheses are not confirmed, or the evidence remains very weak, the accumulated knowledge will be used to explain (or speculate) why the desired outcomes were not achieved. Lessons from both 'successes' and 'failures' are valuable products from this monitoring effort; these lessons will be summarized in reports and presentations. The results of this monitoring will likely provide valuable lessons and insights that can be applied to similar projects and studies in the future, and to guide adaptive management decisions.